ISSN: 2688-8645

Research Progress on the Remediation of Heavy Metal Contaminated Soil by Edible Mushrooms

Liheng Xia[1, 2, 3, 4, 5, *], Jing Zhang[1, 2, 3, 4, 5]

[1]Shaanxi Provincial Land Engineering Construction Group Co., Ltd, Xi'an, 710075, China

[2]Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd, Xi'an, 710075, China

[3]Key Laboratory of Degraded and Unused Land Consolidation Engineering, Ministry of Natural Resources, Xi'an, 710075, China

[4]Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an, 710075, China

[5]Land Engineering Technology Innovation Center, Ministry of Natural Resources, Xi'an, 710075, China

*18092729601@163.com

Abstract

Using edible mushrooms for remediation of heavy metals in soil as the research content, the research results on the mechanism of heavy metal enrichment by edible mushrooms, the ability of edible mushrooms to adsorb heavy metals, the The research results of edible mushroom species used to remediate heavy metal contaminated soil and the remediation technology of edible mushrooms on heavy metal contaminated soil are summarized The research results are summarised and evaluated, problems are analysed and future research directions are explored, with a view to providing a theoretical reference for the comprehensive management and remediation of heavy metals in soil. The research results are summarised and evaluated. At the same time, based on the current hot issues of soil heavy metal pollution in agricultural production, several feasible soil remediation technologies are proposed, which can be used for the remediation of foodstuffs. This study will provide research and application ideas for the remediation of soil heavy metals by edible mushrooms.

Keywords

Edible mushrooms; Heavy metal contamination; Soil remediation.

1. Research on the Mechanism of Heavy Metal Enrichment by Edible Mushrooms

The ability of edible mushrooms to remediate heavy metal contaminated soil is mainly due to their enrichment of heavy metals [1], mainly from biological and sorption effects [2]. The main reason for the ability of edible bacteria to remediate heavy metal contaminated soil is their strong enrichment effect on heavy metals [3], mainly from biological and sorption effects [4]. From the perspective of plant cell physiology The main physiological steps in the adsorption of heavy metals by edible mushrooms are explained from a plant cell physiology perspective and include The main physiological steps in the adsorption of heavy metals by edible mushrooms include: extracellular accumulation, adsorption on the cell membrane surface and intra-cytoplasmic The main physiological steps of heavy metal adsorption by edible mushrooms

ISSN: 2688-8645

include: extracellular accumulation, cell membrane surface adsorption and intracellular accumulation, where extracellular accumulation is limited to living cells.

1.1. Biological Action

Biological action refers to the entry of heavy metal elements into the fungal cytoplasm when inside the fungal cytoplasm, its macromolecular reactive groups bind to the heavy metal ions to form insoluble substances or precipitates, or special enzymes are produced in the cytoplasm to reduce The heavy metals are accumulated or desorbed into the edible metals are accumulated or desorbed into the cytoplasm of edible mushrooms. For example, mushrooms of the (Agaricus) are mainly bound to heavy metal ions by specific metal conjugates similar to metallothioneins in plants. specific metal conjugates similar to metallothionein in plants, and are taken up and transferred into Agaricus macrosporus cotyledons have a Cd-binding activity in the cytoplasm of the mushroom [5]. Agaricus macrosporus cotyledons contain an organic compound that binds Cd and the The main reason for the higher Cd content in the cotyledons of Agaricus macrosporus is the presence of Cd-binding proteins [6]. protein [7]. Some fungi can also catalyse the breakage of carbon-mercury bonds through organic mercury lytic enzymes, relying on Cd binding proteins [8]. Some fungi can also catalyse the breakage of carbon-mercury bonds through organic mercury lyases, relying on reduced coenzyme II (NADPH) and The fungus can also catalyse the breakage of the carbon-mercury bond through organic mercury lyase, relying on reduced coenzyme II (NADPH) and active vitamin B2 (FAD) as coenzymes as dimerases Mercury reductase reduces inorganic $Hg2+$ to $Hg0$, rendering it non-toxic toxic state into or out of the bacteriophage [9].

1.2. Adsorption

Adsorption refers to the adsorption of heavy metals from the soil by the mycelium of edible fungi. The process follows the pattern of absorption by the edible fungus, through passive transport across the plasma membrane and through the plasma membrane by passive transport and the formation of inorganic deposits in the mycelial cells. Inorganic precipitation is formed in the mycelium cells. For example, mycorrhizal edible fungi can secrete sulphate compounds The mycorrhizal edible fungus can secrete sulphate compounds that bind hexavalent chromium, convert it to trivalent chromium and accumulate in ion exchange sites in the cell wall. The ion-exchange sites in the cell wall [10]. In addition, edible mycelium can also In addition, edible mycelium can actively transport heavy metal ions. The heavy metal ions are converted to Cr heavy metal ions in the cell wall of the mycelium and the reactive groups (e.g. sulfhydryl, carboxyl, hydroxyl, etc.) After a chemosynthetic reaction with reactive groups in the cell wall (e.g. sulfhydryl, carboxyl, hydroxyl, etc.), they consume energy and cross the protoplasmic The heavy metal ions are used up in the cell wall to produce insoluble substances or precipitates. Soil Manganese, copper, iron and zinc can be transported into fungal cells in this way [11]. Ozcan et al.[12] suggest that edible fungi can be enriched by active transport of heavy Ozcan et al.[30] suggested that edible fungi can enrich heavy metals through active transport and accumulate more heavy metals than green plants, and Severoglu et al. et al.[13] also found that edible mushrooms contained higher concentrations of nickel, cadmium, chromium and lead than soil. Cd, Cr and Pb.

2. Study on the Selection of Edible Fungal Species for Remediation of Heavy Metals In Soil

2.1. Types of Biological Contamination Indicators

As wild edible mushrooms occur naturally in the appropriate environment in the environment, the growth process is not influenced by any human factors. Therefore, the for enrichment in soil can give a visual indication of the environment in which they grow and the ability of

ISSN: 2688-8645

different species of wild mushrooms to adsorb The ability of different species of wild bacteria to adsorb different heavy metal elements, such as Boletus spp. can be used as an indicator of the Hg content of soil in the field; in areas where truffles occur (Tuber spp.) can be used as an indicator of soil Hg content in the field; in areas where Tuber spp. occurs, the enrichment of Pb by Tuber spp. The Pb enrichment of Tuber spp. can be used as an indicator of soil Pb contamination in the field. Some artificial edible fungi such as Coprinus comatus, Coprinus comatus) can be used to monitor Pb contamination in the environment [14]; Ganoderma lucidum (Ganoderma lucidum) as a bioindicator to detect environmental Ganoderma lucidum is used as a bioindicator to detect caesium contamination in the environment [15]; edible mushrooms as bioindicators are not only accurate but also The use of edible mushrooms as bioindicators is not only highly accurate but also extremely cost effective.

2.2. Types of Soil Remediation

Many edible mushrooms are used for trial planting with some cash crops, such as Auricularia auricula [16], Agaricus Bisporus [17], Plain mushrooms in maize fields [18], and Agaricus Bisporus [19], Pleurotus spp. (Pleurotus spp.) [20], straw mushroom (Volvariella volvacea) [21], etc. The crop patterns such as mushroom-grain and mushroom-vegetable are used to reduce the enrichment of heavy metals in crops. The crop-grass and mushroom-vegetable cropping patterns can reduce the enrichment of heavy metals in crops. Macrofungi can also modify the presence of heavy metals in the soil to reduce plant enrichment. They can also reduce the uptake of heavy metals by plants by altering the form of heavy metals present in the soil[22]. Edible mushroom cultivation Waste materials (e.g. bran, residue, spent mushrooms) are also good sorbent materials for for example, waste from the cultivation of golden and shiitake mushrooms can adsorb heavy The waste from cultivation of golden and shiitake mushrooms can adsorb soil heavy metals to improve soil conditions [23].

2.3. Soil Heavy Metal Irrigation Water Sorption Species

The mycelium-laden substrate material can be made into a variety of filters that intercept and treat a variety of polluted water bodies; microbial organisms themselves or metabolites, can flocculate and fix pollutants in water bodies [24]. García-Delgdo et al.[25] showed that in agricultural irrigation, Agaricus bisporus (Agaricus bisporus) is a very useful filter for the treatment of polluted water. The results of García-Delgdo et al.[26] showed that Agaricus Bisporus culture waste in irrigated agriculture was able to The results of García-Delgdo et al.

3. Research on Edible Mushroom Remediation Technology for Heavy Metals In Soils

3.1. Combined Edible Bacteria-engineered Bacteria Restoration Technology

Li et al [27] conducted bioremediation of heavy metal contaminated soil by inoculation of soil bacillus with Agrocybe aegerita) for bioremediation of heavy metal contaminated soil. The combined use of mushrooms and bacteria for the remediation of heavy metal contaminated soils is a This study used Agrocybe aegerita and Serratia marcescens for the bioremediation of Ni-Cd contaminated soil. contaminated soil. The results show that The results showed that inoculation of Tea Tree mushrooms alone or simultaneously with Serratia marcescens in Ni-Cd contaminated soils The results showed that inoculation of Tea-tree mushrooms and Serratia marcescens in Ni-Cd contaminated soil either alone or together increased the biomass of the mushrooms, and inoculation increased the number of bacteria and enzyme activity in the soil, while in the soil, suggesting that these combinations can more strongly This suggests that these combinations are more effective in mitigating heavy metal stress.

3.2. Edible Mushroom Co-restoration Techniques

Co-remediation with edible mushrooms is mainly the use of two or more edible mushroom materials for remediation of heavy metal and compound contaminated soil. the different heavy metal adsorption capacity and advantages of each edible mushroom. This method is suitable for specific mixed contaminated soil situations, such as heavy metal This method is suitable for specific mixed soil conditions, such as heavy metals and organic pollutants. The method is suitable for specific mixed soil conditions, such as soil contaminated with organic pollutants.

3.3. Functional Reagent-assisted Restoration Technology for Edible Mushrooms

Due to the frequency of multiple or compound heavy metal contamination of soils the efficiency and effectiveness of single heavy metal remediation methods for edible mushrooms cannot address the complex and multiple contamination problems in a timely manner. and effectiveness of single heavy metal remediation methods for edible fungi cannot solve complex and multiple contamination problems in a timely manner. In this context, combined heavy metal remediation and co-remediation with edible mushrooms In this context, combined heavy metal remediation and co-remediation technologies for edible mushrooms could be a more efficient way to address this complex multiple It is expected that this technology will be an emerging technology that can be widely It is expected that this technology will become an emerging technology that can be widely applied in soil remediation in the future.

References

[1] Fan Ting, Ye Wenling, Chen Haiyan, et al. Study on heavy metal pollution in agricultural soils and remediation techniques [J]. Journal of Ecology and Environment, 2013, 22(10):1727-1736.

[2] Li Fengguo, Chen Ming, Shi Yanli, et al. Analysis of the current situation of soil remediation of agricultural land in China [J]. Modern chemical industry, 2018, 38(12): 4-9.

[3] Cai Meifang, Li Kaiming, Xie Danping, et al. Study on the status of heavy metal pollution in arable soils in China and countermeasures for prevention and control [J]. Environmental Science and Technology, 2014,37(S2): 223-230.

[4] Sine Limin, Zhao Tongke, Zheng Huai Guo, et al. Progress in remediation technology for soil heavy metal pollution [J]. Environmental Science and Technology, 2014, 37(S2):213-222.

[5] Liang Yaojie. The current situation of soil heavy metal pollution in China and its prevention and control measures [J]. Resource Conservation and Environmental Protection, 2020(1): 98.

[6] Dang Mintuan, Liu Juan, Yang Shan. Research progress of soil heavy metal pollution and treatment [J]. Shaanxi Agricultural Science, 2020, 66(6): 94-96.

[7] Xu Jianhui. Current status of soil heavy metal pollution and remediation methods [J]. Anhui Agricultural Science, 2016, 44(5): 161-162,238.

[8] Shi Yanli, Chen Ming, Li Fengguo, et al. Research progress of soil heavy metal pollution remediation technology [J]. Non-ferrous Metal Science and Engineering, 2018, 9(5):66-71.

[9] Yang CH, Tan PAN, Gui CHENG, et al. Research progress of microbial fuel cells for remediation of heavy metal contaminated soil [J]. Chemical and Biological Engineering, 2020, 37(1):1-7.

[10] Shi Run, Wu Xiaofu, Li Yun, et al. Plant species used in phytoremediation of heavy metal contaminated soils [J]. Journal of Central South University of Forestry Science and Technology,2015, 35(4): 139-146.

[11] Jia Weitao, Lv Sulian, Lin Kangqi, et al. Progress in remediation of heavy metal contaminated soil by high biomass economic plants [J]. Journal of Biological Engineering, 2020,36(3): 416-425.

[12] Wang Qiaohong, Ruan Pengpeng, Li Jun. Strategies for environmental protection of phytoremediation technology in soil pollution treatment [J]. China Resource Utilization, 2020,38(1): 156-158.

ISSN: 2688-8645

[13] Ji Xiuling, Wei Yunlin. Research progress of low temperature microbial environmental pollution remediation technology [J]. Environmental Pollution Control Technology and Equipment, 2006(10): 6-11.

[14] Deng Qin. Discussion on microbial remediation technology for soil heavy metal pollution [J]. Western Leather, 2019, 41(9): 117.

[15] Wang Peng, Zhang Di, Li Jiadong. Research progress of plant-microbial synergistic remediation of heavy metal pollution in soil [J]. Guangdong Chemical Industry, 2017, 44(8): 127-128.

[16] Rajkumar M, Ae N, Freitas H. Endophytic bacteria andtheir potential to enhance heavy metal phytoextraction[J]. Chemosphere, 2009, 77(2): 153-160.

[17] Jiang YB, Ji HB. Bioremediation of heavy metal contaminated water bodies by algae [J]. Advances in Geoscience, 2007, 26(1): 56-67.

[18] An Xinlong, Zhou Qixing. Biological enrichment and ecological remediation of heavy metals by macrofungi [J]. Journal of Applied Ecology, 2007, 18(8): 1897-1902.

[19] Liu Jianfei, Hu Liujie, Liao Dunxiu, et al. Progress in bioremediation of heavy metal pollution by edible mushrooms [J]. Journal of Applied Ecology, 2011, 22(2):543-548.

[20] Zhang D, Gao JW, Zheng YL, et al. Heavy metal content of nine species of wild mushrooms in Liangshan Prefecture, Sichuan [J]. Journal of Applied and Environmental Biology, 2006, 12(3):348-351.

[21] Gao Tingyan, Zhang Dan. Current status and development trend of mushroom biosorption of heavy metals [J]. Science and Technology Advisory Guide, 2007, 4(24): 153-154.

[22] Huang Qing, Li Wei, Guo Xiang, et al. Progress in the enrichment of heavy metals in edible mushrooms [J]. Chinese edible mushrooms, 2014, 33(2): 4-6.

[23] Gast C H, Jansen E, Bierling J, et al. Heavy metals in mushrooms and their relationship with soil characteristics [J]. Chemosphere, 1988, 17(4): 789-799.

[24] Michelot D, Siobud E, Doré J C, et al. Update on metalcontent profiles in mushrooms-toxicological implications and tentative approach to the mechanisms ofbioaccumulation. approach to the mechanisms ofbioaccumulation [J]. Toxicon, 1998, 36(12): 1997-2012.

[25] Pan Yanyuan, Chen Wenli, Huang Qiaoyun. Advances in the metabolism of heavy metals by microorganisms [EB/OL]. Beijing: China Science and Technology Paper Online [2005-11-24]. http://www.paper.edu.cn/releasepaper/content/200511-350.

[26] Petkovšek S A S, Pokorny B. Lead and cadmium in mushrooms from the vicinity of two large emissions sources in Slovenia [J]. Science of the Total Environment, 2013, 443: 944-954.