2.5. Phytoextraction capacity

The phytoextraction capacity was found by multiplying the total amount of Pb (mg/kg) removed from the soil by the plant over-the-surface, surface part and grain and by the amount of soil around 250,000 kg in 1 da area. Enrichment coefficient (EC) is used to determine the degree of heavy metal accumulation of plants growing in contaminated soil [30,31]. Enrichment coefficient was determined as in Equation 1.

"Enrichment Coefficient " ("EC")"=Pb in Plants Shoot/Pb in Soil " (1)

Where the heavy metal element concentration (DM: dry matter) in plant above ground part expressed as Pb in plants shoot and the heavy metal element concentration (extractable in DTPA) (DM) in soil expressed as Pb in soil.

2.6. Statistical analysis

The data were statistically analysed using Minitab 16 and 18.

3. Result and Discussion

3.1. Physical and Chemical properties and Elemental Content of soil

The physical and chemical properties of soil are shown in Table I, that the soil sample is classified as loamy sand based on United States Department of Agriculture (USDA). The soil used in experiments contains very low organic substance percentage, sufficient P, Cu, Mn, and high amounts of Fe and Zn. It was known that the antagonistic effects between Zn and Pb inhibit the translocation of these both elements from root to other parts of plants and Pb-P interaction was reported that it may cause the insoluble P-formation in plants tissue and/or soil [1]. The total Pb content in the soil was 751.5 mg/kg. Kabata-Pendias and Pendias (1984) stated that that the toxic level of Pb for plants was not easy to specify but the threshold concentrations of Pb was given by many investigators in the range of 100-500 mg/kg [32]. The pH value and electrical conductivity were 8.79 as alkaline and 122.3, respectively.

TABLE I: The physical and chemical properties of soil used in experiments

	Texture Class	**$CaCO_3$ (%)**	**pH**	**Electrical Conductivity (µS/cm)**	**Organic Matter (%)**	**Field Capacity (%)**
Soil Properties	Loam sand	23.93	8.79	122.3	0.87	27.34
	Fe (mg/kg)	**Cu (mg/kg)**	**Mn (mg/kg)**	**Zn (mg/kg)**	**P (mg/kg)**	**Total Pb (mg/kg)**
	13.53	2.99	18.32	2.78	18.40	751.5

3.2. Mycorrhizal colonization and its effects on plants biomass

There were no significant differences in plants height, hyphae enter the cells, mycorrhizal infection rate and flower-grain weight at the increasing Pb concentrations which were determined depending on buckwheat species and presence or absence of AM (Table II and III).

TABLE II: The effect of different Pb concentrations treatment on the growth of Aktaş and Güneş buckwheat types

Plant Varieties	**The Doses of Lead (mg/kg)**	**Plant Height (cm)**	**Hyphae Enter the Cells (%)**	**Mycorrhiza Infection Rates (%)**	**Plant Stem Weight (g)**	**Flower and Grain Weight (g)**
AKTAŞ	0	29,9	25	28	7,61 B	0,21
	200	28,9	37	30	9,30 AB	0,30
	400	38,9	58	37	11,21 A	0,36
	800	29,8	68	27	9,50 AB	0,37
GÜNEŞ	0	34,0	40	52	8,69 B	0,28
	200	35,5	42	37	12,24 A	0,40
	400	37,2	53	48	12,85 A	0,34
	800	38,2	52	27	12,14 A	0,28
LSD Value P<0.01		ns-ns	ns-ns	ns-ns	ns-P<0.01	ns-ns

**Capital letters; It shows the statistical differences in the varieties

TABLE III: The effect of mycorrhizae on the growth of Aktaş and Güneş buckwheat types in Pb-contaminated soil

Plant Species	Mycorrhiza Application	Plant Height (cm)	Hyphae Enter the Cells (%)	Mycorrhiza Infection Rates (%)	Plant Stem Weight (g)	Flower and Grain Weight (g)
AKTAŞ	(+)	29,3	78	52	7,88 B	0,26
AKTAŞ	(-)	34,5	16	9	10,93 A	0,36
GÜNEŞ	(+)	34,7	79 A	56 A	11,19	0,31
GÜNEŞ	(-)	37,7	14 B	26 B	11,77	0,34
LSD Value $P<0.05$		ns-ns	ns-$P<0.01$	ns-$P<0.01$	ns-$P<0.01$	ns-ns

**Capital letters; It shows the statistical differences in the varieties

The effect of different lead concentrations in mycorrhiza inoculated buckwheat cultivars on the DTPA-Pb content remaining in the soil, Pb content in grain-flower and stem, the amount of Pb removed from the soil by grain and plant stem, phytoextraction capacity and active enrichment equality value are presented in Table IV. The examination table showed that, the DTPA-Pb content remaining in the soil after trial increased with the increased lead doses. These values ranged from 16.8 to 133.2 mg/kg. In the soil samples taken respectively from each pot following the pot trial, available Pb content was found to be 72.79 mg/kg on average in Aktaş cultivar, whereas it was 78.31 mg/kg in Güneş cultivar. Also, there were observed statistical differences between the interaction of mycorrhizal and Pb in Aktaş cultivar ($P<0.01$). On the other hand, Pb content of plant stem, Pb content of flower and grain, the amount of removed Pb from soil by plant stem and grain, phytoextraction capacity and also active enrichment equality was significantly changes depending on Pb concentrations on buckwheat varieties and presence or absence of AM ($P<0.01$) (Table IV).

TABLE IV: The effect of different lead concentrations in mycorrhiza inoculated buckwheat cultivars on Pb content in grain- flower and stem, the amount of Pb removed from the soil by grain (RSG) and plant stem (RSS) (mg/kg soil), phytoextraction capacity (kg/da) and active enrichment equality

Plant Varieties	Mycorrhiza Application	The Doses of Lead (mg/kg)	DTPA Pb in Soil (mg/kg)	Flower and Grain Pb (mg/kg)	Plant Stem Pb (mg/kg)	RSG Pb (mg/kg soil)	RSS Pb (mg/kg soil)	Phytoextraction Capacity (kg/da)	Active Enrichment Equality
AKTAŞ	(+)	0	18,1 F	0,00 E h	248 F l	0,00 B	2,38 D	0,59 E	13,71 A
		200	55,5 E	0,31D efg	338 E ıj	0,23 B	4,38 CD	1,15 CDE	6,09 B
		400	86,3 CD	0,85 B cd	435 CD fg	0,39 B	6,59 BC	1,74 BCD	5,09 B
		800	110,6 AB	1,60 A b	631 B c	0,40 B	6,81 BC	1,80 BC	5,72 B
	(-)	0	16,8 F	0,00 E h	195 F m	0,00 B	2,68 CD	0,67 DE	11,68 A
		200	65,4 DE	0,58 C de	402 D gh	0,26 B	6,29 BCD	1,64 BCDE	6,16 B
		400	100,6 BC	0,94 B c	489 C e	0,64 B	9,49 B	2,53 B	4,86 B
		800	129,1 A	1,81 A b	753 A b	1,44 A	13,85 A	3,82 A	5,89 B
GÜNEŞ	(+)	0	21,2	0,00 h	283 F kl	0	3,68 E	0,92 E	13,36 A
		200	58,8	0,49 DE ef	365 E hı	0,24	6,94 CDE	1,79 CDE	6,21 BC
		400	98,8	0,87 CD cd	464 D ef	0,59	9,09 BCD	2,42 BCD	4,74 C
		800	124,5	1,73 B b	730 B b	0,75	12,51 B	3,31 B	5,86 BC
	(-)	0	27,7	0,17 EF gh	306 F jk	0,08	4,17 DE	1,063 E	11,19 A
		200	55,8	0,25 EF fgh	322 EF jk	0,19	6,01 DE	1,55 DE	5,90 BC
		400	106,5	1,07 C c	561 C d	0,40	11,20 BC	2,90 BC	5,26 BC
		800	133,2	2,24 A a	992 A a	0,95	20,05 A	5,253 A	7,48 B
LSD Value $P<0.01$(varieties)			ns	0,292-$P<0.05$	39,43-$P<0.01$	ns-ns	ns-$P<0.01$	ns-$P<0.01$	ns-$P<0.01$

* Lower case letters show the statistical differences between varieties **Capital letters; It shows the statistical differences in the varieties

Soil factors such as soil texture, pH, cation exchange, as well as plant factors such as root surface area, root exudates, transport rate of mycorrhizas affect plant Pb uptake [33]. Pb accumulation depends on the type of the plant, cultivars, plant organ, concentration of lead, and the presence of other ions in the environment. Pb transport is more effective in plant cultivars with high shoot/root Pb concentration. It was reported that the accumulation of Pb in *Thlaspi rotundifolium* plant is 130-8200 mg Pb/kg [34]. Plants with slow growth and low biomass are not suitable for phytoextraction of Pb from the contaminated soil [33]. When the soils contain high, potentially toxic amounts of heavy metals, mycorrhizal formation usually induces lower concentrations of these metals in the aerial part of the plant and consequently has a beneficial effect on plant growth [35,36]. In a study, it was found that buckwheat could accumulate 1500 mg kg-1 DW of Pb in leaves and removed about 200 mg of Pb per m^2 from the soil [20]. In another study, it was determined that buckwheat accumulated 4000 mg Pb/kg [19]. It was observed that buckwheat accumulated some heavy metals within itself in various previous phytoremediation studies, but there is not enough information about the translocation of heavy metals to the grain. In this study, in order to control the transition of Pb to the grain, buckwheat was grown in soil contaminated with Pb at different concentrations. Pb content in flower-grain (mg/kg) increased statistically significant with applied lead doses between both varieties and also within the varieties ($P<0.01$ and $P<0.05$). Values are between 0.00-2.24 mg/kg. Mycorrhizal inoculation again decreased grain's Pb content.

A similar situation was also true for plant stem Pb content. Stem Pb content was between 195-992 mg/kg, which was considerably higher than that of the grain-flower component. There was a significant difference between the species also in terms of plant stem Pb content ($P<0.01$). While average Pb content was 436 mg/kg in Aktaş species, it was 503 mg/kg in Güneş species. Average Pb content was 437 mg/kg in mycorrhizae-inoculated plants, whereas it was 503 mg/kg in plants that were not subjected to mycorrhizal inoculation. Stem Pb content showed a statistically significant increase with increasing doses of lead. The highest average Pb content was observed as 992 mg/kg in the concentration of 800 mg Pb/kg at Güneş variety. Besides, lead content was higher in applications without mycorrhizal inoculation compared to the others. In this case, it can be said that plant growth and development measured through phenological observations were found to be better in mycorrhizae-inoculated plants compared to non-mycorrhizal plants due to the fact that mycorrhizal inoculation decreased the Pb intake in these plants and the plants became more resistant. In Japan, the Pb content in BW was 0.36 mg/kg on average [37]; for various plants, the Pb content in the grass at the roadside was changed to 67-950 mg/kg in Sweden [38]. The total Pb concentration of the wheat plant grown in dirty soil having 861 and 2400 mg/kg Pb content was 1660-1820 mg/kg DW in the body part [39].

The content of lead taken from the soil by the grain and the surface part of plants increased with increasing Pb doses ($P<0.01$) (Tablo IV). The Pb taken from the soil was less in mycorrhiza inoculation doses compared to not inoculated ones; mycorrhiza inoculation negatively affected this situation. In other words, plants having mycorrhiza inoculation removed less Pb from the soil compared to those without mycorrhiza. In addition, Pb intake from the soil in Güneş cultivar was more compared to Aktaş cultivar; while the amount of Pb taken from the soil (RSS) was 13.85 mg/kg in the case of 800 mg Pb/kg soil application in the Aktaş cultivar, the Pb uptake in Güneş cultivar was 20.05 mg/kg in the same application.

The phytoextraction capacity was also higher in Güneş cultivar than those in Aktaş buckwheat cultivar. Phytoextraction capacity in Güneş cultivar was 0.92 and 1.06 kg Pb/da in control application and 5.25 kg/da at the concentration of 800 mg Pb/kg in the treatment of AM(-). In Aktaş cultivar, it was 0.59 and 0.67 kg Pb/da in control application while the highest value was 3.82 kg/da in the case of at concentration of 800 mg Pb/kg in the treatment of AM(-). This value showed a significant increase with increasing lead doses ($P<0.01$) (Table IV).

Enrichment coefficient is used as an important criterion to assess the degree of accumulation of metals in the roots and shoots of the plants with respect to their concentration in the growing medium. The value of the active enrichment equation, i.e. the proportion of the lead in the form that can be taken from the soil with the plant body, changed between 4.74 and 13.71. The rate of activation, which is high in those with mycorrhizal inoculation and control applications, decreased with increasing doses of Pb, but the values were not found to be statistically significant (Table IV). This rate was significantly reduced with increasing doses of Pb ($P<0.01$) (Table IV-V).

TABLE V. The effect of different concentrations of Pb on buckwheat on Pb content from the soil by stem, phytoextraction capacity and active enrichment equilibrium

Concentrations of Lead (mg/kg)	RSS Pb (mg/kg soil)	Phytoextraction Capacity (kg Pb/da)	Active Enrichment Equilibrium
0	0,43 c	0,81 d	12,48 a
200	0,62 b	1,53 c	6,09 b
400	0,79 a	2,40 b	4,99 c
800	0,86 a	3,55 a	6,24 b
LSD Value P<0.01	0,147	0,47	0,968

In a study conducted by Kumar et al (2013) in order to determine the heavy metal accumulation potential of twelve native weed, all the plants were found to have an enrichment coefficient greater than 1, which reflects their high metal accumulation potential [31]. EC was ranged from 1.105 (Cd in *S. nigrum*) to 609.157 (Cr in *T. procumbens*) and from 0.866 (Cd in *S. xanthocarpum*) to 1130.372 (Cr in *T. procumbens*) in roots and shoots of studied plant cultivars, respectively.

4. Conclusion

Significant differences were observed between the buckwheat cultivars in terms of the examined characteristics. When the general mean values were taken into account, the Pb content taken from the soil by plant stem was higher in Güneş cultivar than Aktas cultivar. This value was 13.85 mg Pb/kg in the Aktaş cultivar at concentration of 800 mg Pb/kg whereas it was 20.05 mg Pb/kg at the same concentration in Güneş cultivar. Also it was 6.81 mg Pb/kg in the Aktaş cultivar and 12.51 mg Pb/kg in Güneş cultivar at the concentration of 800 mg /kg Pb with inoculated mycorrhiza. It was determined that the amount of Pb taken from the soil by the plant stem was far higher than Pb which taken from soil by the grain. Although AM inoculation positively affects the development of the plant, it has a negative effect on plant Pb uptake. AM inoculation decreased the amount of Pb taken from the soil by the plant stem and the grain. The plant’s root spreads over a larger area in the root zone, also with the effect of the hyphae that enter the root zone of the plant and utilizes the plant nutrient elements, and thus the plant becomes selective and decreases Pb uptake. In both buckwheat cultivars, it was observed that AM hyphae entry was through the roots and inoculation occurred. Therefore, it was concluded that the buckwheat was a plant that could receive mycorrhizal inoculation. By the way, the content of Pb in the grain was also very low and it changed between 0.00-2.24 mg/kg DM.

Consequently, the buckwheat plant is the candidate hyperaccumulator plant for Pb, however, the AM inoculation was not suitable to enhance the phytoremediation capacity of buckwheat.

References

[1] A. Kabata-Pendias and H. Pendias, Trace Elements in Soils and Plants, 3th ed. Boca Raton , Florida: CRC Press, 2001, pp. 225-231.
https://doi.org/10.1201/9781420039900

[2] C. Lin, J. Liu, L. Liu, T. Zhu, L. Sheng, and D. Wang, “Soil amendment application frequency contributes to phytoextraction of lead by sunflower at different nutrient levels,” Environmental and Experimental Botany, vol. 65, pp. 410–416, 2009.
https://doi.org/10.1016/j.envexpbot.2008.12.003

[3] M. D. Jusselme, F. Poly, E. Miambi, P. Mora, M. Blouin, A. Pando, C. Rouland-Lefevre, “Effect of earthworms on plant Lantana camara Pb-uptake and on bacterial communities in root-adhering soil,” Science of the Total Environment, vol. 416, pp. 200–207, 2012.
https://doi.org/10.1016/j.scitotenv.2011.10.070

[4] K. A. Alaboudi, B. Ahmed, and G. Brodie, “ Phytoremediation of Pb and Cd contaminated soils by using sunflower (Helianthus annuus) plant,” Annals of Agricultural Sciences, vol. 63, pp. 123–127, 2018.
https://doi.org/10.1016/j.aoas.2018.05.007

[5] H. Abbaslou, S. Bakhtiari, and S. S. Hashemi, “Rehabilitation of Iron Ore Mine Soil Contaminated with Heavy Metals Using Rosemary Phytoremediation-Assisted Mycorrhizal Arbuscular Fungi Bioaugmentation and Fibrous Clay Mineral Immobilization,” Iran J Sci Technol Trans Sci, vol. 42, pp.431–441, 2018.
https://doi.org/10.1007/s40995-018-0543-7

[6] D. Guo, A. Ali, C. Ren, J. Du, R. Li, A. H. Lahori, R. Xiao, Z. Zhang, and Z. Zhang, “EDTA and organic acids assisted phytoextraction of Cd and Zn from a smelter contaminated soil by potherb mustard (Brassica juncea, Coss) and evaluation of its bioindicators,” Ecotoxicology and Environmental Safety, vol. 167, pp. 396–403, 2019.
https://doi.org/10.1016/j.ecoenv.2018.10.038

[7] Z. Ghori, M. HiraIftikhar, M.F. Bhatti, N. Minullah, I. Sharma, A. Kazi, and P. Ahmad, “Phytoextraction: The Use of Plants to Remove Heavy Metals from Soil,” Plant Metal Interaction Emerging Remediation Techniques, pp. 385-409, 2016.
https://doi.org/10.1016/B978-0-12-803158-2.00015-1

[8] D. Sarkar, S. S. Andra, S. K.M. Saminathan, and R. Datta, “ Chelant-aided enhancement of lead mobilization in residential soils,” Environmental Pollution, vol. 156, pp. 1139–1148, 2008.
https://doi.org/10.1016/j.envpol.2008.04.004

[9] A. Wallace, E. Romney, G. Alexander, S. Soufi, and P. Patel, “Some interactions in plants among cadmium, other heavy metals, and chelating agents,” Agronomy Journal, vol. 69, pp. 18-20, 1977.

https://doi.org/10.2134/agronj1977.00021962006900010005x

[10] E. V. Freitas, C. W. Nascimento, A. Souza, and F. B. Silva, “Citric acid-assisted phytoextraction of lead:A field experiment,” Chemosphere, vol. 92, pp. 213–217, 2013.

https://doi.org/10.1016/j.chemosphere.2013.01.103

[11] S. D. Veresoglou, B. Chen, and M. C. Rillig, “ Arbuscular mycorrhiza and soil nitrogen cycling,” Soil Biology & Biochemistry, vol. 46, pp. 53-62, 2012.

https://doi.org/10.1016/j.soilbio.2011.11.018

[12] C. Tonin, P. Vandenkoornhuyse, E. Joner, J. Straczek, and C. Leyval, “Assessment of arbuscular mycorrhizal fungi diversity in the rhizosphere of Viola calaminaria and effect of these fungi on heavy metal uptake by clover,” Mycorrhiza, vol. 10, pp. 161-168, 2001.

https://doi.org/10.1007/s005720000072

[13] T. R. Cavagnaro, S. F. Bender, H. R. Asghari, and M. G.A. van der Heijden, “The role of arbuscular mycorrhizas in reducing soil nutrient loss,” Trends in Plant Science, Vol. 20, No. 5, pp. 283-290, May 2015.

ttps://doi.org/10.1016/j.tplants.2015.03.004

[14] S.-Q. Li, and Q.H. Zhang, “Advances in the development of functional foods from buckwheat,” Critical reviews in food science and nutrition, vol. 41, pp.451-464, 2001.

https://doi.org/10.1080/20014091091887

[15] T. B. Pirzadah, B. Malik, I. Tahir, M. Kumar, A. Varma, and R. U. Rehman, Soil Remediation and Plants: Prospects and Challenges, USA, Elsevier, 2015, pp. 107-130.

https://doi.org/10.1016/B978-0-12-799937-1.00005-X

[16] J.F. Ma, S.J. Zheng, S. Hiradate, and H. Matsumoto, “Detoxifying aluminum with buckwheat,” Nature, vol. 390, pp. 569–570, 1997.

https://doi.org/10.1038/37518

[17] J.F. Ma, and S. Hiradate, “Form of aluminum for uptake and translocation in buckwheat (Fagopyrum esculentum Moench),” Planta, vol. 211, pp. 355–360, 2000.

https://doi.org/10.1007/s004250000292

[18] J.F. Ma, “Syndrome of aluminum toxicity and diversity of aluminum resistance in higher plants,” Int. Rev. Cytol., vol. 264, pp. 225–252, 2007.

https://doi.org/10.1016/S0074-7696(07)64005-4

[19] H. Tamura, M. Honda, T. Sato, and H. Kamachi, “Pb hyperaccumulation and tolerance in common buckwheat (Fagopyrum esculentum Moench),” Journal of Plant Research, vol. 118, pp. 355-359, 2005.

https://doi.org/10.1007/s10265-005-0229-z

[20] M. Honda, H. Tamura, T. Kimura, T. Kinoshita, H. Mastsufuru, and T. Sasto, “Control of lead polluted leachate in a box-scale phytoremediation test using common buckwheat (Fagopyrum esculentum Moench) grown on lead contaminated soil,” Environmental technology, vol. 28, pp. 425-431, 2007.

https://doi.org/10.1080/09593332808618805

[21] F. Tani, and S. Barrington, “Zinc and copper uptake by plants under two transpiration rates. Part II. Buckwheat (Fagopyrum esculentum L.),” Environmental pollution, vol. 138, pp. 548-558, 2005.

https://doi.org/10.1016/j.envpol.2004.06.004

[22] G.J. Bouyoucos, “A recalibration of the hydrometer method for making mechanical analysis of soils,” Agronomy journal, vol. 43, pp. 434-438, 1951.

https://doi.org/10.2134/agronj1951.00021962004300090005x

[23] S. R. Olsen, and L. E. Sommers, Methods of soil analysis: Part 2, 2nd ed. Madison, Wisconsin USA, 1982, pp. 403–430.

[24] A. Walkley, and I.A. Black, “An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method,” Soil Science, vol. 37, pp. 29-38, 1934.

https://doi.org/10.1097/00010694-193401000-00003

[25] M. Jackson, “Soil Chemical Analysis-Advanced Course: A Manual of Mehods Useful for Instruction and Research in Soil Chemistry, Physical Chemistry of soils, Soil Fertility and Soil Genesis,” ML Jackson, 1969.

[26] W.L. Lindsay, and W.A. “Norvell, Development of a DTPA soil test for zinc, iron, manganese, and copper,” Soil science society of America journal, vol. 42, pp. 421-428, 1978.

https://doi.org/10.2136/sssaj1978.03615995004200030009x

[27] R. Koske, and J. Gemma, “A modified procedure for staining roots to detect VA mycorrhizas,” Mycological Research, vol. 92, pp. 486-488, 1989.

https://doi.org/10.1016/S0953-7562(89)80195-9

[28] M. Giovannetti, and B. Mosse, “An evaluation of techniques for measuring vesicular arbuscular mycorrhizal infection in roots,” New Phytologist, vol. 84, pp. 489-500, 1980.

https://doi.org/10.1111/j.1469-8137.1980.tb04556.x

[29] S. Wong, X. Li, G. Zhang, S. Qi, and Y. Min, “Heavy metals in agricultural soils of the Pearl River Delta, South China,” Environmental Pollution, vol. 119, pp. 33-44, 2002.

https://doi.org/10.1016/S0269-7491(01)00325-6

[30] G. Kisku, S. Barman, and S. Bhargava, “Contamination of soil and plants with potentially toxic elements irrigated with mixed industrial effluent and its impact on the environment,” Water, Air, and Soil Pollution, vol. 120, pp. 121-137, 2000.

https://doi.org/10.1023/A:1005202304584

[31] N. Kumar, K. Bauddh, S. Kumar, N. Dwivedi, D. Singh, and S. Barman, “Accumulation of metals in weed species grown on the soil contaminated with industrial waste and their phytoremediation potential,” Ecological Engineering, vol. 61, pp. 491-495, 2013.

https://doi.org/10.1016/j.ecoleng.2013.10.004

[32] A. Kabata-Pendias, and H. Pendias, Trace elements in soils and plants, Boca Raton, CRC press, 1984.

[33] P. Sharma, and R.S. Dubey, “Lead toxicity in plants,” Brazilian Journal of Plant Physiology, vol. 17, pp. 35-52, 2005.

https://doi.org/10.1590/S1677-04202005000100004

[34] R. Reeves, and R. Brooks, “European species of Thlaspi L.(Cruciferae) as indicators of nickel and zinc,” Journal of Geochemical Exploration, vol. 18, pp. 275-283, 1983.

https://doi.org/10.1016/0375-6742(83)90073-0

[35] A. Gildon, and P. Tinker, “Interactions of Vesicular-Arbuscular Mycorrhizal Infections and Heavy Metals in Plants,” New Phytologist, vol. 95, pp. 263-268, 1983.

https://doi.org/10.1111/j.1469-8137.1983.tb03492.x

[36] A. Heggo, J. Angle, and R. Chaney, “Effects of vesicular-arbuscular mycorrhizal fungi on heavy metal uptake by soybeans,” Soil Biology and Biochemistry, vol.22, pp. 865-869, 1990.

https://doi.org/10.1016/0038-0717(90)90169-Z

[37] K. Kitagishi, and I. Yamane, “Heavy metal pollution in soils of Japan,” January 1981.

[38] A. Ruhling, and G. Tyler, “Ecology of heavy metals--a regional and historical study,” Botaniska Notiser, 1969.

[39] Y. Chen, X. Li, and Z. Shen, Leaching and uptake of heavy metals by ten different species of plants during an EDTA-assisted phytoextraction process,” Chemosphere, vol. 57, pp. 187-196, 2004.

https://doi.org/10.1016/j.chemosphere.2004.05.044