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PREFACE

Special issue on "Soil and plant contamination and remediation, Part 2"

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Background

This collection of papers submitted to this Special Issue is mainly an outgrowth from the Session SSS7.3. EGU 2020 "Progress in assessment of soil and plant contamination on the global, regional and local scales and approaches to remediation of the polluted mining, urban and rural areas", held in Vienna, May 2020. The pollution of soils and plants and their location in different climatic, physiographic and geochemical conditions require not only constant monitoring of the soil conditions, but also the development of differentiated approaches to assess and prevent the risk of pollution. The development of technologies for the rehabilitation of soil properties, including its fertility, is also a challenge. The problem of soil monitoring and rehabilitation is becoming increasingly topical due to the population expansion to abandoned mining areas as well as other industrial areas.

This Special Issue contains 16 papers written by authors from 15 countries: Armenia, Australia, Canada, Chile, China, France, Iran, Pakistan, Peru, Poland, Russian Federation, Saudi Arabia, South Korea, Spain and Vietnam. In the following paragraph, I will summarize the content and main results of these papers published in this Special Issue. The order of papers is based on submission data.

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Content and main results of the Papers of this Special Issue

Tran et al. (2022) investigated the soil contamination and health risk assessment from heavy metals exposure in vicinity of the Pb–Zn and Au mining area in Bac Kan province, Vietnam. Soil samples were prepared by a modified Aqua Regia method and analysed by ICP-MS for As, Cd, Co, Cu, Ni, Pb and Zn. Results showed that concentration of As, Cd, Pb and Zn exceeded the Vietnamese standard for As and Pb for residential soil. According to Enrichment Factor and Pollution Index results, the soil near Pb–Zn mine showed that the average concentrations of Pb and As were the highest contamination factors in the soil near Pb–Zn mine and Au mine, respectively. Health risk assessment indicates that children were at higher than adults in both non-carcinogenic and carcinogenic risk.

Ghazaryan et al. (2022) assessed of Cu accumulation capacity and phytoremediation suitability of *Artemisia absinthium* L. and the influence of some chelating agents and their combinations of Cu phytoremediation effectiveness. Results have shown that *A. absinthium* is well adapted with ability to grown in Cu-contaminated soils from the surroundings of Zangezur Cu-Mo combined (SE Armenia). It was possible to restore he decrease in plant growth in contaminated soil with MH_4NO_3. For remediation of Cu-contaminated soils by the phytostabilization method, *A. absinthium* can be grown without chelating agents;

being a perennial herb, it is able to accumulate high quantities of Cu in its root while avoiding transfer it to the shoots. For cleaning of Cu-contaminated soils through phytoextraction method by *A. absinthium*, the application of chemical amendments such as citric and malic acids besides NH_4NO_3 is necessary.

Bayat et al. (2022) investigated the effects of sunflower on the bioremediation of Ni, Cr, Pb and Cd on the sewage sludge in greenhouse and field conditions in Isfahan, Iran. Soils polluted with sewage sludge, soil pH and $CaCO_3$ were not affected, but soil salinity, organic matter and soil N were significantly increased. Sewage sludge was significant on plant uptake of Ni, Cr, Cd and chlorophyll b, total chlorophyll and carotenoids in the field. Although Pb was not affected by sewage sludge, it showed the highest bioaccumulation factor. The heavy metals were all positively and significantly correlated with each other and with plant carotinoids. The increased levels of carotenoids, acting as antioxidant, may be an indicator of oxidative stress. Sunflower can be used for bioremediation of the soils polluted with sewage sludge including Ni, Cr and Cd.

Nandillon et al. (2022) researched the potential of *Salix viminalis* L. associated with *Trifolium repens* L. for the phytostabilization of biochar-amended contaminated soils by assessing: (1) the tolerance of both plants to metal(oid)s, through the biomass production, (2) the concentrations of metal(oid)s in plants and (3) the concentrations of metal(oid)s in pore water and percolation waters. For these objectives, mono- and polycultures were carried out on As- and Pb-contaminated mining soil amended with biochar. Results showed that willow and clover polyculture produced lower dry clover biomass than in monoculture. Willow biomass was not affected by the presence of clover. The combination of willow and clover in a phytomanagement would be more appropriate than their monoculture.

Konopleva and Sanzharova (2022) investigated the vertical distribution of ^{137}Cs in bog meadows. Based on soil properties in the Bryansk region, Russia, fifteen years after the Chernobyl Nuclear Power Plant accident, the peak of ^{137}Cs activity (92%) was still in the upper 10 cm. layer of a drained transitional bog. The lowest part of the initial ^{137}Cs deposition (40%) has been found in 0–10 cm. horizon in lowland bog with the deep peat layer. The findings revealed that elevated soil moisture promotes ^{137}Cs downward migration. It was shown that NH_4^+ has a major impact on mobility of ^{137}Cs in bog soils. In wet bog soils, ^{137}Cs migrated downwards more rapidly than in the soil of the drained bog. This is due to the low NH_4^+ content in the upper layers of the drained bog soil.

Mola Ali Abasiyan et al. (2022) prepared using a green route ionically chitosan/sodium alginate hydrogels containing nano-cellulose (CSA-N) and chitosan–sodium alginate hydrogels without nano-cellulose (CSA). The authors characterized the sorbents by FTIR, SEM and XRD and investigated the influences of initial Cd^{2+} concentration, the presence of nano-cellulose, the type of the polluted environment and ionic strength on adsorption and desorption isotherms. The results indicated that Langmuir and Freundlich models provided the best fit for the experimental adsorption data for CSA and CSA-N, respectively. By comparing the amounts of Δq, the difference between adsorption and desorption amounts, the CSA was not economically feasible[2] at high initial concentrations of Cd^{2+} in the wastewater system, while CSA-N demonstrated to be a more efficient adsorbent than CSA for Cd^{2+} removal from both the soil and wastewater systems.

Vodynitskii and Minkina (2022) proposed a new index to determine the affinity of heavy metals (HM) to carrier phases ($A_{HM\text{-}fraction}$), because the degree of metal extraction (C_{HM}) shows a maximum dependence on the strength of reagent, but not on the affinity of metal for the extracted phases. This index is distinguished from the old index pC_{HM} by an additional constant that takes into consideration the sum of all HM in the given phase as a share from the sum of bulk content of all HM in the soil. The new one takes into consideration any discrepancy in the affinity of the given metal for phases recovered by different strength reagents. Siderophility of HN depends on the properties of iron oxides: Cu and Ni show affinity for amorphous iron oxides (ferrihydrite); Cu and Pb display affinity for crystalline oxides (magnetite and goethite). Organophility of Cu, Pb and La is only realized in the uncontaminated alluvial soil. Contaminated soils are affected by additional factors that weaken the fixation of classic organophilic metals.

Weber et al. (2022) described an optimized isolation method of humin fraction from the soil by removing its soluble organic and mineral components. A modified method of HA and FA extraction

with 0.1 M NaOH was used in the first step. Then, the mineral components in the residue were digested several times with the 10% HF/HCL until the mineral fraction was almost completely digested to obtain the highest possible yield with the lowest ash content, without affecting humin chemical structure. The results showed that the proposed procedure, adapted to isolate the large amounts of humin, is characterized by a high efficiency and recovery of humin; therefore, it can be used to isolate high amounts of humin from soil.

Gorovtsov et al. (2022) researched the effect of combined pollution by PAHs and heavy metals (HM) on the topsoil microbial communities of Spolic Technosols of Lake Atamanskoe, Southern Russia, using a metagenomics approach. The studied soils contain high concentrations of HM and 16 priority PAHs. Its microbial communities demonstrate an excellent adaptability level in their complexity and diversity, as shown by the high values of alpha-diversity indices. Regardless of contamination levels, the share of Actinobacteria and Proteobacteria was consistently high. From the results of the Mann–Whitney U-test, there were significant changes of less abundant phyla. The abundance of oligotrophic bacteria from Gemmatimonadetes and Verrucomicrobia phyla and autotrophic bacteria decreased due to the high PAHs level. Abundance of Firmicutes and amoeba-associated bacteria such as TM6 and Chlamydia increased in highly contaminated plots.

Conesa and Párraga-Aguado (2022) assessed the response of metal availability to the addition of two organic amendments (a municipal waste biosolid and a tree biochar) separately and, in combination, in a metalliferous mine tailings substrate. A comprehensive comparison among single extraction procedures and a sequential extraction were performed. The effects on metals phytotoxicity were assessed with a germination test using seeds of *Zygophyllum fabago*. The biochar was effective in decreasing metal extractable concentrations, especially for Cd, Mn and Zn, and also showed better germination parameters than the rest of the unamended and amended treatments. The use of the municipal organic biosolid increased labile metal concentrations and potentially available metal pools assessed with EDTA and did not contribute to achieve better results of seed germination. The positive effect of biochar associated to the municipal biosolid supported the suitability of using biochar/biosolid combinations in field applications.

Karimi et al. (2022) review detailed insight into various bioremediation technologies for reduction or removal of pesticides in contaminated soils. Bioremediation methods such as biostimulation, natural attenuation and bioaugmentation have recently been considered for their simplicity and cost-effectiveness benefits. Biodegradation is a relatively slow process, and certain microorganisms must be considered to achieve sufficient degradation. Bioaugmentation results from the addition of pre-grown microbial populations to eliminate pollutants. Biostimulation comes from the addition of nutrients into native microbial populations. The combination of phytoremediation and bioaugmentation, which leads to rhizoremediation, can improve the results of these methods alone. Electrokinetics and washing of soil may achieve high efficiency. A combination of electrolysis with other methods such as Fenton's reagent, ultraviolet light and ultrasound irradiation showed good evidence of removing pesticides in soil treatment. The use of composts and similar materials due to the use of natural materials and microorganisms can be a better, less risky method to deal with environmental pollution.

Kalinichenko et al. (2022) developed a new amelioration and remediation technology based on the phosphogypsum utilization in Haplic Chernozem of South European facies in Rostov Region, Russia. The phosphogypsum was applied to the soil layer at 20–45 cm during intra-soil milling. The Cd thermodynamic forms in soil solution were calculated with the mathematical chemical-thermodynamic model and program ION-3. The form of ion in soil solutions was considered accounting the calcium-carbonate equilibrium (CCE) and association of ion pairs $CaCO_3$ 0, $CaSO_4$ 0, $MgCO_3$ 0, $MgSO_4$ 0, $CaHCO_3+$, MgHCO3+, $NaCO_3$ −, $NaSO_4$ −, CaOH+ and MgOH+. For calculation of the equilibrium of microelements concentration in soil solution ion including heavy metals, the coefficient of microelement association k was proposed. The stabilized pH reduced Cd^{2+} bioavailability that ensures soil health and environment quality of the plant biological product.

Painecur et al. (2022) determined the concentrations of As, Ba, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sr, V and Zn in attic dust in the City of Coronel, Chile, to evaluate their source and assess the risk of health effects

in adults and children. The authors collected attic dust samples from 19 houses. The concentrations of these elements were measured in ICP-OES after Aqua Regia digestion of < 75 µm dust sample. The medians (mg kg^{-1}) were: As 16, Ba 154, Cd 0,8, Co 12, Cr 38, Cu 107, Mn 698, Ni 51, Pb 66, Sr 131, V 129 and Zn 815. The exploratory data analysis shows that Ni, Cu, Cr, Zn, Pb and As distribution is dominated by anthropogenic sources. Principal component analysis shows 4 factors: one is geogenic, and the other three are related to transport emissions and industry. The median of cumulative non-carcinogenic risk value for attic dust was 3.49 for children that indicates an elevated risk.

Vodyanitskii et al. (2022) proposed new index to determine the affinity of heavy metals (HM) to their carrier phases (AHM fraction), which in contrast to the traditional index CHM = 100 CHM fraction / CHM soil, considers the sum of all metals in the fraction as a share of the bulk content of all HM in the soil. The metal has affinity for the given phase if AHM fraction > 1; vice versa, the affinity is absent if AHM < 1. The new index takes into consideration the discrepancy in affinity of the given metal for phases extracted by different strength reagents. The effect of the new indicator was tested on several contaminated soils, such a calcaric, fluvic and arenosol in the contaminated soils in the Rostov region, Russia. Compared with the index CHM, the results of the new analysis of contaminated soils with the ATM fraction demonstrated that their Zn content is decreased due to its low buffer capacity. The proposed method is distinguished by a weak influence of hydroxylamine-hydrochloride on metal extraction. Thus, the use of a new indicator-the affinity of HMs to their carrier phases $A_{HM\text{-}phase}$ showed an advantage over the traditional $index_{HM}$.

Zheng et al. (2022) researched under anaerobic conditions changes of Hg and CH_3Hg^+ (MeHg) content and Hg methylation in Liaohe estuarine, China, *Suaeda salsa* soils under different salinity. The authors simulated indoor incubation at constant temperature whether the changes of salinity (ck, 0.5, 1.0, 1.5 and 2.0%) affected sulphate-reducing bacteria (SRB) and dominated the formation of MeHg. The lowest Hg content is found in the subsurface *S. salsa* soils at 2.0% salinity. Results also show that MeHg in soil was mainly derived from in situ methylation of soil. The methylation of Hg in soil by sulphate-reducing bacteria count in the anaerobic environment both showed a significant positive correlation, while in the late incubation period the correlation decreased.

Nahaeed et al. (2022) studied the combined influence of salinity and Ni on growth and physiological attributes of quinoa (*Chenopodium quinoa* Willd.). Thirty-day-old healthy and uniform seedlings of quinoa genotype A7 were exposed to different concentrations of Ni and their combinations for three weeks. Results showed that plant growth, pigments and stomatal conductance decreased with increased Ni concentrations in nutrient solution. The concentration of Na was increased, while K and Ni decreased under the combined treatment of Ni and salinity. Multivariate analysis revealed that a moderate level of salinity had positive effects on growth and Ni phytoremediation potential of quinoa. The higher tolerance index, bioconcentration factor and lower translocation factor depicted that quinoa genotype A7 can be cultivated for phytostabilization of Ni under salinity stress.

Conclusions

The subject of the Part 2 of this Special Issue is of great importance, and the 16 papers cover significant aspects of fundamental theoretical and applied research in soil contamination and human health and providing advances to the existing knowledge.

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