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PREFACE

Special issue "Soil and plant contamination and remediation: Part 1"

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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 condition, 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 population expansion to abandoned mining areas as well as other industrial areas. It was especially important evaluate the variation and spatial distribution of natural and man-made associations of macro and microelements as a key to understanding the dynamics of sustainability of natural and anthropogenic substances and their spatial structures formed in soils that we need to know to return to safe operation of polluted land.

This Special Issue contains 20 papers written by authors from 14 countries: Algeria, Armenia, Brazil, China, Cuba, India, Finland, France, Nigeria, Pakistan, Russian Federation, Spain, Sweden and Turkey.

This collection of papers is manly focused on eight topics:

1. Mining and industrial wastes; urban sewage sludge.
2. Organic pollutants.
3. Biochar.
4. Nanoparticles, Nanosorbents.
5. Clays.
6. Phytostabilization.
7. Antibiotics in chicken manure.
8. Bromine and Neodymium.

In the following paragraph, I will summarize the content and main results of these papers published I this Special Issue.

Research topics

Mining and industrial wastes; urban sewage sludge

There are eight papers in this Special Issue dealing with the first topic, mining and industrial wastes; urban sewage sludge:

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Jordán et al. (2021) assessed the bioavailability, mobility and leaching of phosphorus in a calcareous soil (NE Spain) amended with different doses of biosolids. The experiment was conducted on percolation columns. Results showed that the pH decreased by as much as 0.89 units, as well as the assimilable and soluble P, obtaining maximum values of 254 mg P kg^{-1}, and 1455 g P kg^{-1}, respectively, and the P present in the leached water, which not surpass 95 g P L^{-1}. The carbonated nature of the investigated soil greatly prevented the movement and los of P from the soil on percolation columns. The diffraction of X-rays points to the formation of oxycalcium phosphate with diffractograms similar to those of apatites.

Martinez et al. (2021) studied the transfer of Cd, Pb, Zn and As to a Mediterranean forest close to five tailing ponds in Cartagena-La Union mining district (SE Spain) also evaluated the effect of the rhizosphere of native *Olea europaea* and *Pistacia lentiscus* on soil properties and sequential chemical extraction. Results showed that there was no influence of the rhizosphere in the total concentration of metal(loids) in soil, decreasing as Pb>Zn>As>Cd. A high percentage of Cd and As was found in the soil labile fractions. The accumulation in vegetal tissues was only high for Pb in *P. lentiscus* roots. Translocation factors showed transfer of Pb and Zn in *O. europaea* and Zn in *P. lentiscus* to aerial parts. The *O. europaea* species was related to soil labile metal (loids) fractions and pH, total N, organic C and silt content. The *P. lentiscus* species were associated to immobilized metal (loid) fractions, sand content, EC and total As, Cd and Pb.

Ediagbonya et al. (2021) investigated metals accumulation in soil dumpsites in four local government areas in Ondo State, Nigeria, using proton induced X-ray emission. The data were analyzed using version 24.0 of the IBM SPSS in Windows. Results show: in Odigbo, for Al,Zn, Co, the highest mean concentration recorded; In Okitipupa, for Si, K, Cr, S, Y, reported the highest mean concentration; in Irele P, Fe, Rb, Sr, Bi, Au, showed the highest mean concentration; in Ilaje, the highest value was observed for V, Cu, As, Zr, Sn, Pb. In the control site, Cl and Mn had an exponential increase in value. The authors found that some of the obtained concentrations were higher than the regulatory limits of the Soil-7 IAEA and WHO.

Alfaro et al. (2021) evaluated the risk assessment of heavy metals in soils and edible parts of vegetables grown on sites contaminated by slag from an abandoned steel plant in Habana, Cuba. The authors determined the total, environmentally available, and bioavailable concentrations of Cd, Cr, Pb and Ni in the soils and the metals bioconcentration factors in the plants. Also, the risks to human health from food and soil ingestion were estimated. Cd was the most bioavailable metal. Rhizosphere mechanisms may increase Cr availability, while accidental ingestion of contaminated soil is the predominant human exposure route for Pb.

Jamil et al. (2021) evaluated of agricultural soil contaminated by industrial effluents of Hayatabad, Peshawar (HIEP) and Gadoon industrial states, Sawabi (GIES) of Khyber-Pakhtunkhuwa, Pakistan, through multivariate geo-statistical tools. Cluster analysis and principal component analysis, along with geo-statistical approaches were applied to highlight geogenic and anthropogenic sources of pollution. It has been observed that soils of both industrial states were highly affected with heavy metals. The Pb concentrations on these target areas occurred in an extremely polluted category. This study indicates that majority of toxic heavy metals contributed to soil pollution in the studied areas are coming from industrial and commercial activities. Heavy metals from these industrial units not only contaminate the soils, but also possesses worsening threats to eco-biota and human beings.

Bakina et al. (2021) studied the effect of soil contamination with oil on biochemical parameters and productivity of ryegrass and clover in a long-term bioremediation experiment. It was found that plants respond differently to oil contamination of Soddy-podzolic soil. Clover was more resistant to oil than ryegrass. Biosynthesis of photosynthetic pigments was not disturbed in clover. The content of oxidative enzymes in clover leaves was 2-10 times higher than in ryegrass. Higher basal respiration in soil planted with clover corresponded to the enhanced oil biodegradation. The greater remediation ability of clover in comparison with ryegrass is a more rapid reduction in soil toxicity.

Chaplygin et al. (2021) focused on the influence of soil pollution in the impact zone of the Lake Atamaskoe (South of Russia) on the ultrastructure of roots and leaves of *Verbascum thapsus* L. Contamination of the studied technosols with Mn, Cr, Ni, Cu, Zn, Pb and Cd has been established with the highest concentration of Zn. Also, pollution with Zn, Pb, Cr

and Zn was determined in plants of *V. thapsus* growing in these technosols. The most significant changes in the ultrastructure of plants under the influence of the pollution impact were found in the cell organelles of leaves (mitochondria, plastids, perixosomes, etc., including spatial transformation of the thylakoid system of plastids).

Álvarez-Robles et al. (2021) studied the differential response of *Oryza sativa* L. and *Phragmites australis* L. plants in trace elements (TEs) contaminated mining soils from Sierra Minera of La Union-Cartagena (SE Spain) under flooded and unflooded conditions in a pot experiment. Both species shower an excluder behavior, retain preferentially the TEs in the roots and limiting their accumulation in the shoots. Soil EC and elevated metal (mainly Cd and Zn) soluble concentrations conditioning the survival of the plants. Whereas, As accumulation in the aerial part of both species influenced the most oxidative stress homeostasis. *Ph. Australis* cultivation showed to be the best option for the phytostabilization of mine soils highly contaminated with TEs, under both flooded and unflooded conditions.

Organic pollutants

Four papers in this Special Issue refer to the second topic, organic pollutants:

Halfadji et al. (2021) assessed the phytoremediation potential of *Avena sativa* and *Vicia sativa* through pot cultivation experiments of different levels of PCB-contaminated Algerian soils of different physicochemical parameters. The removal rate of seven PCBs was examined 40 and 90 days. The presence of *A.sativa* and *V.sativa* reduced the overall PCB content, ranging initially from 1.53 to 127.9 mg kg^{-1}. *V.sativa* is more efficient in the long-term dissipation of PCBs in the highly polluted soil. An average dissipation ratio f 50% was mainly due to microorganisms in the moderately polluted soil. The less contaminated soil had a dissipation ratio of about 24% for both plants and a predominant dissipation of the low chlorinated PCBs.

Minkina et al. (2021) carried out laboratory experiments of comparison of the adsorption capacity of Haplic Chernozem granular activated carbon and biochar in relation to benzo[a]pyrene (BaP) from water solution. The BaP isotherm sorption by the Haplic Chernozem is better illustrated by the Freundlich model than the Langmuir equation. The adsorption dynamic involves two steps. The first one is associated with a fast BaP adsorption on the large available surface and inside macro and meso-pores of the sorbent particles of the granular activated carbon and biochar. Then, the adsorption is followed by a slower process of BaP penetration into the microporous space and redistribution into a hydrophobic fraction.

Keswani et al. (2021) review the comparative occurrence of the organochlorine pesticides (OCPs) in human and bovine milk samples around the globe and portray the negative impacts encountered through the long history of OCP use. The authors focused their pan global survey on the following topics: impact on ecosystem, human exposure, OCs toxicity and global impact of OCBs, failure to take urgent precautionary actions may result in severe health consequences. The precautionary principle includes that chemical should not be discharged into the environment until they are proven to be harmless. The precautionary actions recommended by the authors are: (1) Replacement of OC substances with less harmful alterations, (2) Re-evaluation of production technique, products and human activities to minimize the ill effects, (3) Provision of information and education of the public to minimize the exposure to possibly harmful substances such as OCs, and (4) Education and awareness generation about the ill effects of OCPs and their correct handling among the farmers.

Sushkova et al. (2021) studied the influence of carbon-containing such biochar and granulated activated carbon (GAC) and mineral sorbents, such tripoli and diatomite, on the toxicity of soil contaminated with benzo[a]pyrene (BaP) during phytotesting. Evaluation of the BaP removing efficiency was carried out using the phytotesting method with spring barley in Haplic Chernozem contaminated with different levels (200 and 400 μg kg^{-1}) of BaP. The optimal dose of carbonaceous sorbents into the soil contaminated with 200 μg kg^{-1} was 1%, decreasing the BaP content up to 57–59% in the soil. The optimal dose of the mineral sorbents was found to be 1.5%, which decreased the BaP content in the soil up to 41–48%. An improvement was observed in the morpho-biometric parameters of the plant and the sowing qualities of seeds. Under similar conditions, carbonaceous sorbents were more effective than mineral ones.

Biochar

There are two papers in this Special Issue referring to the third topic, biochar:

Mazarji et al. (2021) evaluated the effectiveness of biochar derived from sunflower husks as a mediator in the heterogeneous Fenton process catalyzed by hematite toward the degradation of benzo[a]pyrene (BaP) in Haplic Chernozem. The effects of operating parameters such as hematite dosaje and H_20_2 concentrations were investigated with respect to the removal efficiency of BaP. The overall degradation of 65% correspond to the H_20_2 to Fe ratio of 22,1. Moreover, the biochar amendment showed an increment in the removal efficiency and promotion in the growth of spring barley. The BaP removal was reached 75 and 95% after 2.5 and 5% w/w addition of biochar, respectively. This enhancement was suggested to result from biochar to activate H_20_2 directly and mediate electron transfer between Fe^{3+} and Fe^{2+}.

Jiang et al. (2021) researched the Pb toxicity alleviation in vater spinach grown of pot experiments in Pb-spiked soil treated with biochar and $CaCl_2$. Results showed that both treatments improved soil health, increased growth and decreased Pb uptake. While, the Pb detoxification mechanism of biochar and $CaCl_2$ is totally different. Biochar immobilize Pb, increase water spinach growth and reduce Pb uptake by water spinach. Meanwhile, exogenous Ca induced Pb stress alleviation may be attributed to Ca-dependent inactivation of Pb^{2+} in the form of plant cell wall deposits, which is almost irrelevant to soil properties.

Nanoparticles, nanosorbents

There are two papers in this Special Issue referring to the fourth topic, nanoparticles, nanosorbents:

Verma et al. (2021) conducted a model experiment in the greenhouse to study the interaction of ZnO-nanoparticles (NPs) on soil taking maize as the test crop. XRD, FTIR, SEM and PSA of engineered NPs confirmed that the material was ZnO–NPs (particle size-65,82 nm.). The application of ZnO–NPs resulted in a significant decrease soil pH and organic carbon and a significant high EC and a significant increase in available P and Zn and Fe. A decrease of dehydrogenate enzyme activity, microbial biomass carbon and microbial counts were recorded on treating the soil with NPs. Since the present examination was carried out in pot, the real scenario may be dissimilar under the field condition, where climatic as well as several other factors may vary and interact in a complex way.

Kumari et al. (2021) review in depth the ability of metal (loid) nanomaterials as nanosorbents along with their applications in soil remediation. The first emphasis of this review has been the use of nanoscale metal (loid) adsorbents for contaminated soil remediation along with their geochemistry. The second focus is on the ecotoxical impacts with special attention to morpho-physiological alterations in edible plants, in topics such: ecotoxicological responses of common metal (loid) nanosorbents, effects on germination and growth, effects on physiological and biochemical indices, uptake and translocation.

Clays

One paper in this Special Issue refers to the fifth topic, clays:

Jordá et al. (2021) characterized seven clays from the province of Alicante (SE Spain) and their possible use in improving the fertility, water absorption and contaminant retaining capacity of degraded soils. Illite was present in all soils. Some samples also contained kaolinite and abundant lime. Soil organic matter was detected in the second derivative of the FTIR spectra by the signals of the CH_2 groups at 2850 and 2919. The FTIR spectrum could be useful to estimate the organic matter content and the CEC. The studied soils did not show heavy metal pollution. Salinization risk seemed to be the most probable cause of degradation. Results show that clay C2, rich in illite, moderate amounts of lime and high amounts of organic matter, has the highest water holding capacity and could be used in degraded soils to improve both CEC and soil water.

Phytostabilization

One paper in this Special Issue refers to the sixth topic, phytostabilization:

Iftikhar et al. (2021) performed a hydroponic experiment to unravel the effects of salinity on modulation of Pb tolerance and phytoremediation potential of quinoa. Four-week-old plants of quinoa genotype “Puno” were treated with different

concentrations of NaCl and Pb. It was noticed that plant biomass, chlorophyll contents and stomatal conductance of quinoa were slightly affected at 150 mM NaCl or 250μM Pb, but the higher concentrations caused a decline in these attributes. The combination of salinity and Pb increased H_2O_2 contents and caused lipid peroxidation that was mitigated by the activation of antioxidant enzymes. Pb uptake and tolerance potential of quinoa genotype "Puno" is suitable for phytostabilization of Pb under saline conditions.

Antibiotics in chicken manure

One paper covers the seventh topic of this Special Issue, antibiotics in chicken manure:

Xu et al. (2021) studied by means of field experiments the changes of soil tetracycline antibiotic residues, resistant bacteria and resistance genes treated with different types and dosage of chicken manure. Results showed that application of chicken manure increased soil organic matter and catalase activity and increased the quantity of tetracycline-resistant bacteria in soil. The amount of soil resistant bacteria was higher in decomposed chicken manure treatment than in fresh chicken manure treatment. Application of chicken manure significantly increased the abundance of resistance genes in the soil, which was more effective in fresh chicken manure treatment. The risk of tetracycline antibiotics to soil ecological environment may be greatly reduced after chicken manure is decomposed.

Bromine and neodymium

One paper in this Special Issue refers to the eighth and last topic, Bromine and Neodymium:

Shtangeeva et al. (2021) researched the bioavailability and toxicity of bromine and neodymium for plants grown in soil and water. The authors used a greenhouse experiment to study effects of bromine and neodymium on wheat seedlings grown in soil and water. The wheat seedlings were capable of accumulating large amounts of both Br and Nd. Compared to the soil-grown plants, the water-grown plants accumulated higher concentrations of the trace elements. Compared to control, the concentrations of Br and Nd in the plant roots increased 215 and 340 times, respectively, while in the soil-grown wheat seedlings, the increase of Br and Nd plant concentrations was 10 times less. The bioaccumulation of Br and Nd resulted significant variations in the concentrations of several elements.

Conclusions

The content of this Special Issue is of great importance, and the 20 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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