



Reclamation and management of polluted soils: options and case studies

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1 Background

The collection of papers presented in this Special Issue is an outcome of the SSS8.2 Session “Reclamation and Management of Polluted Soils: Options and Case Studies” of the European Geosciences Union Conference held in Vienna, April 2016.

Soil is the essential base of the biosphere, limited and fragile resource of mankind, food and drinking water. Therefore, soil quality must be preserved. However, the nature of soils is often altered by mismanagement of industrial and mining activities, energy generation; the increase of traffic, overuse of agrochemicals, and waste disposal are causing worldwide concern, especially in relation to the food chain and human health. The management and reclamation of polluted soils are not easy. There is a growing interest in the development of sustainable new options of management and innovative technologies of reclamation. This Special Issue deals with new data about identification, site investigation, assessment, eco-friendly, and cost-efficient remediation, monitoring and adequate management of contaminated areas. The papers of this issue cover important aspects of fundamental and applied research and provide advances in relation to existing knowledge.

This Special Issue contains 25 papers written by authors from 18 countries: Australia, Austria, Chile, China, France, Germany, India, Italy, Japan, Jordan, Pakistan, Peru, Philippines, Poland, Portugal, Russia, Spain, and Turkey. This collection of papers is mainly focused on eight topics: (1) microbial and enzymatic activities, (2) mine soils, (3) soil-plant interactions, (4) urban soils, (5) organic pollution, (6) sequential extraction, (7) radionuclides, and (8) pollution and soil properties.

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2 Research topics

2.1 Microbial and enzymatic activities

Wang et al. (2017) investigated the combined bioremediation of soil co-contaminated with Cd and endosulfan by *Pleurotus eryngii* and *Coprinus comatus* and the effects on the soil biochemical indicators and microbial counts of co-contaminated soils. The authors used pot experiments and sequential extraction procedure. The results indicated that the combined bioremediation exerted the best remediation effect for co-contaminated soils.

Campos et al. (2017) examined the effect that wood ashes may have on the soil microbial activity on the basis of the dehydrogenase activity and soil oxygen consumption. Different wood ashes proportions and time dependence have been used to make comparisons. The authors found that ashes coming from olive marc and vine shoots may affect positively the soil respiration and the fertility, if they are applied in moderate amounts.

Nadimi-Goki et al. (2017) investigated the enzyme dynamics in contaminated paddy soils under different cropping patterns (NE Italy). The authors monitored the effects of four crop rotation systems (rice-rice-rice: R-R-R, soya-rice-rice: S-R-R, fallow-rice: F-R and pea-soya-rice: P-S-R) on the activities of six important soil enzymes during rice growth. The results suggest that the activity of most enzymes decreases with the following order: drained soil > late waterlogging > early waterlogging > moist soil. The best rotation system for chitinase, leucine aminopeptidase, and β -glucosidase activity was R-R-R, while for arylsulfatase and phosphatase activities were the S-R-R.

Rico Hernandez et al. (2017) analyzed the survival of *Escherichia coli*, total coliforms, and *Salmonella* spp. in a soil amended with urban sewage sludge due to its potential use in soil rehabilitation and to the risk of microbial pollution. The authors found that long periods of time reduce the risk from the presence of pathogens in soils, and the persistence

may be closely related to the treatment of sewage sludge and the initial amount of microorganisms in the sewage sludge.

Rajput et al. (2017) explored in this review the possible toxic effect of various nanoparticles (NPs) on crops and microbial communities. The authors analyzed the major sources of NPs to the environment and their effects of metal-based NPs on the microbiota, plants, and human health. They found that the exposure of soil to nanoparticles causes a decrease in soil microbial biomass, enzymatic activity, and biological diversity.

2.2 Mine soils

Lebrun et al. (2017) evaluate the phytostabilization capacity of *Salix viminalis* to remediate an As and Pb highly contaminated mine technosol amended with biochar and assessed their particle size and dose application effects. The authors concluded that fine biochar particles allowed *S. viminalis* growth on the contaminated soil allowing this species to be used for technosol phytostabilization.

Lam et al. (2017) assessed the adaptive capacity of species *Gazania rigens* and *Pelargonium hortorum* in copper mine tailings in the Antofagasta Region (Chile) one of the most arid in the world. The bioconcentration factor demonstrated that both species act as excluders of Fe, Mn, Pb, Al, and Zn. Also these species present characteristics of potential accumulators of Cu.

Minkina et al. (2017a, b) studied of Cu^{2+} , Zn^{2+} , and Pb^{2+} forms by sequential fractionation in mine and smelter technosols in Karabash, Southern Urals, Russia. The results shown that the distributions of Cu, Zn, and Pb forms in these technosols are due to the composition of pollutants, the time of the contamination, and the buffer properties of the polydisperse system of soils and parent materials.

Romero-Baena et al. (2017) reviewed the role of mineralogy and geochemistry to assess the hazard of soil contamination by trace elements in three mining areas of Andalusia (South Spain): (1) Linares-La Carolina (Pb-Zn ores), (2) Riotinto (Iberian Pyrite Belt), and (3) Aznalcollar mines (Iberian Pyrite Belt). The authors found that the oxidation of pyrite releases As and heavy metals that can be sequestered by sulfate-arsenate or efflorescent sulfates. Iron oxy-hydroxides were more stable, and they retained the contaminants at oxidant conditions. Cd, Zn, and Pb tend to be adsorbed at high pH, and As was adsorbed by clays and iron-oxy-hydroxides.

Pérez-Sirvent et al. (2017) assessed the potentially toxic elements (PTEs) contamination in mine soils from Portman Bay (SE Spain). The authors used selective chemical extraction of Pb, Cd, Zn, Cu, and As in order to evaluate the potential mobility of metals. The highest PTEs content were obtained in the oxidizing medium. The mineralogical composition and the degree of weathering are decisive on the PTEs mobility.

2.3 Soil-plant interactions

Neu et al. (2017) researched the trace elements bioavailability to *Triticum aestivum* and to the earthworm *Dendrobaena veneta* in a multi-element contaminated agricultural soil amended with drinking water treatment residues (WTR). The authors examined the use of WTR based on Fe and (hydro)oxides as a cost-effective solution in the immobilization of Cd, Pb, Zn, and As. They found that a bioassay with key species prior to field application should be perceptive in situ stabilization options. They concluded that low-application rates of WTR improve biomass; higher rates involved risks.

Rafiq et al. (2017) compared the efficiency of EDTA and calcium in alleviating arsenic toxicity in *Vicia faba*. The authors performed two separate experiments: *V. faba* seedlings grown under As-hydroponic conditions and grown in As-contaminated sand culture in presence and absence of EDTA and CaCl_2 . The results showed that EDTA and Ca greatly affect AS accumulation and toxicity to *V. faba*, and the effect varies greatly with their applied levels as well as type and age of plant organs.

Rocco et al. (2017) assessed the changes induced by 5 years of native plant revegetation in the chemical properties and mobility bioavailability of Pb and Zn pollutants of soil and post-washing sludges from an Italian brownfield. The authors used sequential extractions to fractionate Pb and Zn forms. Plant ability to uptake metals was evaluated on *Bituminaria bituminosa*, *Daucus carota*, and *Dactylis glomerata*. After revegetation, the pH decreased, the organic carbon content increased and enhanced the solubility in water of metal-containing compounds.

Liberati et al. (2017) researched a phyto-dehydration of confined sludge as a sustainable approach for the management of polluted ponds. A mesocosm-scale trial was carried out to test the capacity of different helophyte species to reduce the excess of water in an artificial pond filled with oversaturated sludge. This phytotechnology can be a suitable strategy to manage excess of water in polluted ponds.

2.4 Urban soils

Rodriguez-Bocanegra et al. (2017) assessed the heavy metal tolerance in *Brassica juncea* and *Solanum lycopersicum* in an experimental-disturbed polluted soil. This soil was highly contaminated by Cu, Pb, and Zn. The two plants had an ability to transport heavy metals from the roots to the shoots, especially for Zn. Great concentration of the studied metals, in the drainage water, after irrigation of plants was observed.

Kosheleva et al. (2017) investigated the conditions of the lateral migration of potentially toxic elements and identified the zones of their accumulation in soil catenas of ore mining landscapes in the cities of Zakamensk (Buryat Republic, Russia) and Erdenet (Mongolia) which are situated in the

basin of the Selenga River. The authors used the catenary approach and the concept of lateral geochemical barriers and found an increased content of sand with W, Mo, Cd, Bi, Pb, and Sr derived from the tailings by water erosion in Zakamensk and of silt particles windblown with V, Co, Sr, and As in Erdenet.

Tume et al. (2017) researched the potentially toxic elements in urban soils of Talcahuano, Chile. The authors determined the concentrations and background levels of Ba, Co, Cr, Mn, and Ni in soils of Talcahuano, assessed the level of contamination, and identified the natural or anthropogenic sources and the spatial distribution of pollutants. They found a moderate to considerable contamination in some soil samples.

2.5 Organic pollutants

The work of Falciglia et al. (2017a, b) dealing with modeling and preliminary technical, energy, and economic considerations for full scale in situ remediation of low-dielectric hydrocarbon-polluted soils by microwave heating (MWH) technique. The authors found that sandy soils are more penetrable by MW irradiation than clay ones. The soil MW penetrability was also observed to increase with decreasing the soil moisture. The comparison with other clean-up technologies shows that in situ MWH is a deliverable alternative to conventional techniques.

Sushkova et al. (2017a, b) researched for the first time the features of accumulation, migration, and transformation of benzo[a]pyrene (BaP) in soil-plant system by using a new ecologically friendly water extraction method. The authors found a constant of BaP semi-decomposition in chernozems of Rostov Region with different pollution levels and different values of bioaccumulation in plants.

Sushkova et al. (2017a, b) studied the influence of PAHS contamination on soil ecological status monitoring soils and natural grassy vegetation plots established at different distances from Novocherkassk Power Station (NPs). Significant correlations were found between PAHs content and enzymes activity in plots situated through the prevailing wind direction from NPs that is the main pollution source. It was found that contamination of soil by PAHs depends on the activity of all soil biological communities as well as the dehydrogenase and the phytotoxicity of soils.

2.6 Sequential extraction

Burachevskaya et al. (2017) compared two methods of sequential fractionation in the study of copper compounds in Haplic Chernozem under model experimental conditions. The authors found that the Tessier method is more suitable for the separation of the total technogenic components from contaminated soils. The Miller method is more informative at

the determination of loosely bound HM compounds because of the use of weaker extractants.

Weber et al. (2017) assessed the contamination of podzols in a subalpine zone of Karkonosze Mountains, Sudetes, Poland. Cu, Pb, and Zn concentrations and the patterns of their sequential extraction are discussed in relation to the possible influence of air-borne industrial emissions and the stage of degradation of dwarf pine stands. The authors found a high concentration of Pb and Zn organically bound fraction probably caused by a long-distance transport of anthropogenic emissions. The high concentrations of Pb or other metals form in soils cannot be considered to have been the principal causes of the ecological disaster in the Karkonosze Mts.

2.7 Radionuclides

Falciglia et al. (2017a, b) assessed at lab scale the detection efficiency and minimum detectable activity of ^{241}Am and ^{152}Eu of contaminated soils by low-altitude Unmanned Aerial Vehicles equipped with small size γ -ray spectrometer. The authors conclude that all achievements and the calculated fitting parameters are useful preliminary data in the quantitative characterization of soil surface contamination and represent a valuable tool in knowing the soil surface γ -ray activity of ^{241}Am and ^{152}Eu for each given detected value.

Chizhikova et al. (2017) researched the regional specificity of radionuclide fixation in river basins due to soil petrology and mineralogy and its ecological significance. The authors collected alluvial soil samples in Yenisey (Central Siberia) and Iput (East European Plain) and studied of ^{137}Cs distribution in clay minerals. Specificity of local clay minerals as radionuclide sorbents should be of a particular ecological concern in relation to long-term exchange processes of the radioisotope including its transfer to food chains.

2.8 Pollution and soil properties

Minkina et al. (2017a, b) studied the effect of contamination with Cu, Zn, and Pb high rates on the physical properties and organic matter of Haplic Chernozem under model experimental conditions. The authors concluded that under conditions of model experiment, the contamination with high rates of Cu, Zn, and Pb leads to changes of the microaggregate distribution, the structural status, and the qualitative composition of organic matter.

3 Conclusions

The 25 papers described on the eight sections cover important aspects of fundamental and applied research in Soil Science and provide advances in relation to existing knowledge.

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