Environ Geochem Health (2020) 42:1–6
https://doi.org/10.1007/s10653-019-00513-1

EDITORIAL

Soil contamination and human health: Part 1—preface

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Published online: 27 January 2020

Background

The collection of papers submitted to this Special Issue is mainly an outcome of the Session SSS8.5, EGU2018 "Soil contamination and human health: advances and problems of risk assessment", the European Geosciences Union (EGU) Conference held in Vienna, April 2018.

The development of soil geochemistry and geochemical ecology has demonstrated a correlation between concentration of certain elements in soil, their transfer to local food chains and biological reactions to deficiency or excess of the particular elements, including diseases such as goitre, fluorosis, selenosis and cancer. The development of analytical chemistry combined with developing GIS increases the spatial correlation between soil geochemistry and medical data. It is necessary to establish the optimal level for population health and evaluate the spatial distribution of soil chemicals above or below these optimal levels.

This special issue contains 20 papers written by authors from 14 countries: Armenia, Australia, Brazil, China, Germany, India, Latvia, Pakistan, Poland, Russian Federation, South Africa, Spain, USA and Vietnam. This collection of papers is mainly focused on eight topics: (1) mining and industrial pollutants in nearby soils, (2) risk assessment, (3) soil–plant interactions, (4) organic pollutants, (5) selective extraction/fractionation, speciation, (6) urban soils, (7) background of potential toxic elements and (8) nanoparticles.

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Research topics

Mining and industrial pollutants in nearby soils

There are four papers dealing with this topic: mining and industrial pollutants in nearby soils: Timofeev et al. (2019) assessed the impact of the Zakamensk, Baikal region, Russia, W–Mo deposit development on soil surface horizons and the health of the local population. The mortality rates from diseases of the digestive and respiratory organs including neoplasms and malign tumours are growing despite the closure of the mine more than 15 years ago. The tailing dumps and the zone soils have increased concentrations of W, Cd, Pb, Sb, Mo, Cu, Zn, Sn, As and Co.

W, Cd, Pb, Sb, Co, V and Cr cause the greatest harm to adults and children and account for 92–96% of the hazard index. The level of the total risk of developing malignant diseases indicates a catastrophic environmental situation.

Nguyen et al. (2019) analysed 30 soils and polished rice along the Red River in N. Vietnam ad Huong River in Central Vietnam to evaluate soil chemistry, the transfer of harmful elements from the soils into grains and the health risk of the local population from eating rice. The results showed that As, Bi and U in the soils are enriched probably by natural redox processes. Zn, Ce, Th, La, Sn, Pb and Cd are accumulated by mining activities or wastewater application. As exceeds the national allowable limit of 15 mg kg^{-1} soil in 80% of the tested soils, 12% of the polished rice samples surpass the limit of 0.2 mg Cd kg^{-1} grain dry matter.

Zhuo et al. (2019) studied the sources, concentration and risk assessment of heavy metals in the industrial park in Rizhao, Shandong Province, China. The authors used geo-accumulation and potential ecological risk (PER) indexes to assess the pollution levels of the park. Sources of HM were investigated by correlation analysis (CA) and principal component analysis (PCA). PER shows that the soil presented moderate risk level and that the river sediment severe risk level. Hg and Cd were found to pose the highest PER. The results of CA and PCA showed that the main source of HM pollution in the park was industrial activities and atmospheric factors.

The work of Linnik et al. (2019) deals with the geochemical assessment and spatial analysis of heavy metals (HM) pollution around Novocherkassk coal-fired power station, Rostov Region, Russia. The 25 soil samples selected in the area within a radius of up to 20 km revealed enrichment with Pb, Cu and Zn. The HM content in soil follows a decreasing sequence: Mn > Cr > Zn > Ni > Cu > Pb > Co. The correlation diagrams of the HM total content revealed a significant association in the pairs: Cu–Pb, Ni–Cu, Cd–Ni and Cd–Cu ($r \geq 0.7, p < 0.001$). The influence of wind rhumb HM on distribution is complex and nonlinear.

Risk assessment

Three papers in this Special Issue refer to the second topic: risk assessment.

Ramos-Miras et al. (2019) determined Hg and Cr in greenhouse soils (GS) in a semi-arid region in Almeria (South Spain) and assessed the enrichment factor and the Potential Ecological Risk Index (PERI) according to crop age. The results showed that 74% of GS exceeded the background level (37.1 µg kg^{-1}) for Hg with 43% (48.9 mg kg^{-1}) for Cr. After many intensive crop-farming years, concentrations and the PERI had clearly increased. Although the ecological risk was moderate, the observations of authors suggest that the farming practices over the last 35 years allowed the Hg and Cr to accumulate, so 15% of the studied soils presented a considerable PERI.

Kaur et al. (2019) determined the risk exposure of heavy metals (HM) in groundwater and soil and human health in Reasi district, Jammu and Kashmir, lower Himalayas, India. The calculated mean contamination factor of HM in soil samples was Zn 0.73; Cu 0.70; Pb 0.74; and Cr 0.33; which lead to pollution load index less than unity. The concentrations of HM in water and soil samples were found to be less than the values prescribed by various agencies. The value of geo-accumulation index for metals in soil samples indicated no contamination except Pb. The results concluded that children are comparatively highly exposed to the non-carcinogenic doses as compared to adults.

Shah et al. (2019) assessed As exposure via drinking groundwater and associated carcinogenic risk in 15 peri-urban areas of Vehari, Pakistan. 83% of the 127 groundwater samples collected and analysed (As content and physicochemical characteristics) showed mean As content higher than WHO limit. Risk assessment parameters (mean hazardous quotient 3.0 and mean cancer risk 2.0) showed possible carcinogenetic health issues in the area. A cancer risk value of As was predicted up to 3.2 for Mujahid Colony (Burewala). Therefore, drinking water remediation/management strategies must be executed in the area.

Soil–plant interactions

Three papers in this Special Issue deal with the third topic: soil–plant interactions.

Shtangeeva et al. (2019) researched what is the primary factor affecting accumulation of elements in different plant species: soil or the plant itself and how both factors can influence the concentrations of elements in a plant. With this objective, the authors estimate the variations in the concentrations of macro- and trace elements in the rhizosphere soil and in roots and leaves of three widely distributed species: couch grass, plantain and yarrow collected simultaneously from two sites characterized by different soil parameters. The authors found that different species differ widely in their ability to uptake various elements even if they grow in the same soil. The three cited species have different reactions on the soil characteristics.

Yarrow was more tolerant to varying environmental conditions than plantain and couch grass.

Sarvar et al. (2019) evaluated the risk assessment of the build-up of potentially toxic metals in soil–plant system after irrigation with untreated city wastewater in Vehari, Pakistan. Results showed that the mean concentration (mg L^{-1}) of Cd (0.02), Mn (0.25) and Fe (1.57) in wastewater samples was higher than their respective threshold values. Also Cd, Mn and Fe concentration in soil exceeded the permissible limits of agricultural soil after wastewater irrigation. The high accumulation of Pb, Cr and Fe in some plants depends on the crop species. Pb and Cd are major toxic chemical substances to human health, and a daily intake of crop plants constitutes a potential health threat due to wastewater-irrigated crop consumption.

Minkina et al. (2019) analysed the effects of Cu toxicity from contaminated soil in spring barley (*Hordeum sativum distichum*) in Rostov region (South Russia). In this study, barley was planted in a Haplic Chernozem spiked with the concentration of Cu. Cu toxicity was observed to cause slow development of plants, changing shape, size and colour. The ultra-structural changes in roots, stems and leaves were characterized using transmission electron microscopy. The roots were the most affected, showing degradation of the epidermis, reduced number of parenchyma cells, decrease in the diameter of the stele and disruption to its cell structure (endoplasmic reticulum, mitochondria, chloroplasts and perixosomes). Moreover, cellular Cu deposition was observed.

Organic pollutants

Three papers deal with the fourth topic: organic pollutants.

Yang et al. (2019) investigated 43 locations for benzene homologues contaminants in soil, soil gas and groundwater in a former herbicide factory site: distribution, attenuation, risk and remediation and also studied the hydrogeological conditions. An inverse distance weighted interpolation method was employed to determine the pollutants' spatial distribution in the soils. Results showed that benzene homologues residues were originated from the herbicide production workshop. The pollution had horizontally expanded at the deeper soil layer. The primary mechanism for contaminant transport and attenuation included dissolution of "occluded" non-aqueous phase liquids (NAPLs) into pore water and pollutant volatilization into soil pore space. Risk assessment revealed is high, and a remediation of this former factory is urgently required.

Li et al. (2019) researched the influence of nanocarbon on the uptake and transportation of pentachloronitrobenzene (PCNB) from soil to pakchoi (*Brassica napa* var. *chinensis*), their accumulation and the risk to human health. The results indicated that nanocarbon could function as contaminant carriers and promoted the transportation of PCNB from soil to root of pakchoi and their absorption and accumulation by this plant. Human risk assessment showed that people consuming the pakchoi in this study would not experience risk. However, in vitro toxicity test indicated that PCNB could directly impair intestinal epithelial cells and thus pose a potential risk to human intestine.

Konstantinova et al. (2019) investigated the levels, sources, spatial distribution and toxicity of polycyclic aromatic hydrocarbons (PAHs) in urban soils of Tyumen, Russia. Topsoils (0–10 cm) were collected from 241 sites on a regular grid within Tyumen city limits. The median value of PAHs total concentration was 280.3 μg kg^{-1}. High molecular weight (HMW) PAHs were dominant (62%) of the total PAHs. Phenanthrene, pyrene, fluoranthene and benzo[ghi]perylene shared values of 28%, 19%, 15% and 10% from total PAHs, respectively. Cluster analysis and principal component analysis have confirmed that sources associated with the transport were the most significant. Assessment of soil toxicity using the toxic equivalent quantity showed a median of 17.7 μg kg^{-1}.

Selective extraction/fractionation, speciation

Three papers in this Special Issue refer to the fifth topic: selective extraction/fractionation, speciation.

Osibote and Oputu (2019) applied a modified BCR sequential extraction procedure for partitioning and evaluating the mobility and persistence of trace elements (As, Cd, Cr, Cu, Ni, Pb, Sb, Se, Zn) in soils from three landfill sites and sludge samples from Cape Town, South Africa. The BCR fraction in the soils from the three sites was Cu (74–87%), Pb (65–80%), Zn (59–82%) and Cd (55–66%). The mobility of Cu, Zn and Ni ($>$ 95%) was particularly high in the sludge sample. The geo-accumulation index (I_{geo}) and risk assessment code (RAC) were used to assess the environmental risk. Exposure to the soils and sludge did not pose any non-cancer risks to humans. (The hazard quotient (HQ) and the hazard index (HI) values were $<$ the safe level of 1.) The cancer risks from Cd, Cr and Ni require remedial action during closure and restoration of the landfill sites.

Ermakov et al. (2019) assessed the relationship of the mobility of Ca^{++} and Sr^{++} in soils with their levels in meadow plants in the presence of Kashin–Beck endemia in Eastern Transbaikalia (area between the Shika and the Argun rivers). The Ca^{++} and Sr^{++} mobility levels were determined by sequential extraction method of seven soil samples from the endemic region compared with seven control sites. Likewise, the Ca^{++} and Sr^{++} levels of these extracts were compared with their levels in the plants from the both areas. The results show that in the endemic landscapes the Sr^{++} in soils and plants, especially in various species of *Salix*, is increased. Also the abundance of fungi such as species of *Fusarium* genus increased, which may affect the mobility of alkaline-earth elements in soils.

Vodyanitskii et al. (2019) studied common and rare Fe, S, Zn compounds in a technogenically contaminated hydromorphic soil formed after the desiccation of Lake Atamanskoe which has served as a reservoir for liquid industrial waste from the city of Kamensk-Shakhtinckii, Rostov oblast, Russia. The authors used Mössbauer spectroscopy and scanning electron microscopy. Brown iron ochre was removed from a contaminated soil sample and analysed. They found both common minerals (illite, goethite, haematite and gypsum) and rare minerals (schwertmannite, Zn-siderite, partially oxidized magnetite and wustite enriched with Zn).

Urban soils

Two papers in this Special Issue deal with the sixth topic: urban soils.

Adimalla (2019a) present a review about As, Cr, Cu, Zn, Ni and Pb pollution assessment and its associated human health risk evaluation of urban soils from 32 Indian cities (period 2001–2019). The results indicated for these six potentially harmful elements maximum concentrations much higher than Indian and Canadian background values. Higher concentrations of Cr and Ni were distributed in southern, northern and eastern. As and Pb predominate in central, Zn in western and Cu in eastern states of India. As and Cr cause non-carcinogenic and carcinogenic health risk in urban soils in India.

Adimalla (2019b) assessed the contamination status, human health risk and spatial distribution of heavy metals in the urban soils from the Medak Province, India. Forty urban surface soil samples were collected and seven potential toxic elements were analysed: Cr, Cu, Cd, As, Ni, Pb and Zn. Spatial distribution analysis showed that Cu, Cr, Zn and Ni pollutions in western regions of Medak were larger than those in central and eastern regions. The hazard index (HI) values for Cu, Cd, Zn, As, Pb and Ni were below 1. However, HI value for Cr ranged from 3.08E−01 to 2.86E+00 for children. Total carcinogenic risks (TCRs) for Cr values for children and adults were larger than the acceptable threshold value of 1.0E−04. This indicates that Cr poses the greatest carcinogenic risk in Medak Province.

Background of potential toxic elements

One paper in this Special Issue is concerned with the seventh topic: background of potential toxic elements.

Sahoo et al. (2019)carried out a high-density soil geochemical survey in the Parauapebas basin, SE Amazonia, Brazil. The background values were estimated separately for surface and subsurface soils and named as “ambient background” (AB) and “geogenic background” (GB), respectively. The “Q75” recommended for the estimation of quality reference values (QRVs) in Brazilian regulation is considered “normal background level”, while “TIF” with the higher background values represents the so-called mineralized background. Using the normal GB, the data indicate low contamination for most of the samples, except in the Carajás area, that shows high contamination from Cu, Cr and Ni.

Nanoparticles

One paper deals with the eighth and last topic of this Special Issue: nanoparticles.

Rajput et al. (2019) focused their review paper on the ZnO and CuO nanoparticles as a threat to soil organisms, plants and human health. The authors discussed sources of nanoparticles in soil contamination, biogeotransformation of CuO and ZnO in soils, their effects on soil organisms, on edible plants and human health via the food chain. They insist that interaction between plants and nanoparticles is an important aspect for the risk assessment. They conclude that the effect of nanoparticles on food quality and threshold limits should be defined. Little is known about the interactions of nanoparticles in soils with different properties, and they recommend that the application of nanoparticles in field conditions will not be feasible until we reach a complete understanding of phytotoxic effects and impacts on soil organisms and human health.

Conclusions

The subject 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.

Acknowledgements I would firstly like to thank the Co-Guest Editors, Prof. Dr. Elena Korobova (Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, Russian Federation), Prof. Dr. V.V.Ermakov (Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow, Russian Federation), Prof. Dr. Carmen Pérez-Sirvent (Faculty of Chemistry, University of Murcia, Spain), Prof. Dr. Michael J. Watts (School of Biosciences, University of Nottingham) for their valuable collaboration. Moreover, I would like to thank the authors for their contributions and for their patience with the review process as well as the reviewers for their observations. Their efforts have improved the quality of this Special Issue. Help with English from James Dove and IT assistance from Oriol Bech are also greatly appreciated. I am extremely grateful to Prof. Dr. Ming Hung Wong, Editor-in-Chief of EGAH, Ms. Sherine Joseph, Handling Editor, and Crystal Lin Siyi, Assistant to Prof. MH Wong, without whose knowledge and experience this Special Issue could never have been published.

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