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PREFACE

Special issue "Geochemistry, Soil Contamination and Human Health. Part 3."

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Background

This collection of papers submitted to this Special Issue is mainly an outgrowth from the Session ITS2.17/SSS12.2 EGU2020 "Geochemistry, soil contamination and human health: theoretical basis and practical approaches towards improvement of risk assessment", Vienna, May 2020.

Human interaction with the environment has gone through several stages of evolution. Being a product of the natural evolution of living organisms in the biosphere, Homo sapiens as a species evolved in the geochemical conditions of the virgin biosphere. The rapid development of intellectual abilities of this genus allowed, first, to survive in adverse environmental conditions around the whole world, then, to cultivate the land, transform the entire system of biocenoses and now to create a new habitat exclusively for man. The result was a significant geochemical transformation of the virgin biosphere, but a kind of punishment for this progress was the emergence of several endemic diseases of a geochemical nature. Nowadays, a variety of anthropogenic sources of pollution and their location in various natural geochemical conditions require not only constant monitoring of the chemical state of soil, water, air and food products, but also the development of spatially differentiated approaches to assessing the risk of provoked diseases.

This Special Issue contains 18 papers written by authors from 14 countries: Armenia, Australia, Brazil, China, France, India, Iran, Lebanon, Pakistan, Portugal, Romania, Russian Federation, Sri Lanka and Spain.

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 date.

Content and main results of the papers of this Special Issue

El-sherbeny et al. (2022) conducted an experiment on nitrogen fixation (NF) in an experimental farm with a drip irrigation system, at the Atomic Energy Authority, Inshas, Egypt, in order to measure the impact of efficiency symbiotic *Bradyrhizobium* sp. and asymbiotic *Azotobacter* sp. on NF, from air and soil, in the presence or absence of plant residues on the growth and yield of peanut plant. *Bradyrhizobium* sp. inoculation showed nearly the same levels of nitrogen derived from air (Ndfa) to those recorded with *Azotobacter* sp. in both the presence and absence of plant residue application through the two seasons. Results show that both possibility of NF of peanut and nitrogen uptake in the soil are enhanced by field

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inoculation with effective *Bradyrhizobium* sp. with plant residue application.

Kolmykova et al. (2022) studied the sorption properties of natural zeolite-containing tripolite from the Khotynetsky deposit, Oryol region, Russia, to evaluate their ability to purify ground waters contaminated by technogenic Ni^{2+} and Zn^{2+}. According to the obtained data, the sorption of Ni and Zn can be described by a linear isotherm and the process of removing Zn from the solution modelling contaminated aqueous solution is more effective. An increase in the salinity and acidification of the model solution naturally leads to a decrease in sorption of both elements. The natural zeolite-containing deposits of the Khotynetsky deposit may therefore well be used as a natural geochemical barrier for the extraction of technogenic Ni^{2+} and Zn^{2+} and natural waters contaminated with these ions with due regard to the salinity and pH of the waters.

Aruta et al. (2022) carried out a geochemical survey across the Commune of Santiago of Chile and determined the concentration of 53 trace elements on 121 topsoil samples. Multifractal IDW interpolation method (MIDN) was applied to generate geochemical baseline maps of 15 PTEs; the concentration-area plot was applied to MIDW grids to show the fractal distribution of geochemical data. Data of PTEs were elaborated by a new statistical method taking into account both the severity of contamination and its complexity. To discriminate the sources of PTEs in soils, a PCA was applied to data expressed in isometric log-ratio (Ilr) coordinates. Based on PCA results a Sequential Binary Partition was defined. A risk assessment was finally completed to relate contamination sources to their effect in public health. A probabilistic approach based on Monte Carlo method was deemed more appropriate to include uncertainty due to spatial variation of geochemical data across the study area. The use of multivariate statistics and compositional data analysis gave the authors to discriminate the main contamination processes and to observe the existence of secondary phenomena, difficult to constrain.

Berezkin et al. (2022) studied the iodine concentration in drinking waters from aquifers of differing age of Bryansk (2013–2017) and Oryol (2016–2017) regions, Central Russia. Results showed a significant variation of iodine in waters from both regions (Bryansk region—from 0.7 to 44.1 µg/l, $n = 244$ and Oryol region—from 1.12 to 36.8 µg/l, $n = 24$. Low values of iodine in the Bryansk region are characteristic of both surface waters (Quaternary aquifer) and groundwater of the Cretaceous aquifer). High iodine values were noted in the groundwater of the Upper Devonian aquifer, both for the Bryansk and Oryol regions. Drinking water from private wells and surface water (lakes and rivers) of both regions are the poorest in iodine. The highest content in iodine in both regions is typical for deep-laid underground waters. Thus, these waters fed by the Upper Devonian and Cretaceous aquifers can be recommended for the water supply of the populations with iodine deficiency.

Ramires et al. (2022) studied the assessment and spatialization of the risk to human health of potentially harmful elements (PHEs) in the soil for children and adults living in the coal Candiota mines, Brazil. The no carcinogenic risks (HQ) of Cu, Pb, Zn, Ni, Cr, Fe, Mn, Cd, as and Se and carcinogenic risks of As were estimated and spatialized. The results revealed a risk for children exposure to Mn, especially through dermal and inhalation exposure routes. For the oral exposure/route, the greatest contributors to the non-carcinogenic hazard risk were Fe, As and Pb. For the inhalation route also, As and Ni were identifying as the main contributors. As did not present carcinogenic risk to adults. The spatial distribution of non-carcinogenic risk showed that Cr, As, Fe, Pb, Ni, Zn and Cu have higher index Hinc close to the coal mining areas. The use of the human health risk assessment HHRA associated with GIS tools assists in the management of contaminated areas. HHRA provides important information about the sources, exposure routes and target population, as well as, the spatial distribution of contamination areas to indicate the management of priority areas.

Dwibedi et al. (2022) researched the best suited combination of native soil, fly ash and vermicompost from rice nursery based on the changing physico-chemical properties and seedling growth. The experiment was carried out at Chiplima, district of Sambalpur, Odisha, India, and consisting of 21 treatment combinations of soil fly ash and vermicompost was laid out in a factorial complete randomized design with three replications. Fly ash and vermicompost at moderate concentrations ameliorated the physical properties in rice nursery soil that resulted in vigorous rice seedlings through beneficial soil biota as well as better root and shoot development. The porosity, water holding capacity and infiltration rate increased

with the addition of vermicompost while fly ash addition reduced them. Fly ash and vermicompost in moderate quantities smothered soil chemical properties like EC and organic C that increased the availability of N, P, K, B, S and Zn.

Sansom et al. (2022) investigated the cancer risk associated soil distribution of PAHs within the Environmental Justice neighbourhoods of Kashmere Gardens, Fifth Ward and Denver Harbour in Houston, Texas, USA, following the confirmation of two cancer cluster (2019–2021). These neighbourhoods are close to a railyard and former wood treatment plant to have utilized coal tar creosote and contain PAHs. The authors took core soil samples from 46 sites to assess for the presence and concentration of 7 carcinogenic PAHs (USEPA). Results showed the cumulative concentration of these PAHs in each sample was variable with a range of 13,767 ng/g–328 ng/g and a mean of 2,517 ng/g ± 3.122. A regional soil screening evaluation indicates that 40 of the 46 soil samples were in excess of the USEPA lowest bound for elevated cancer risk of 1.0 × 10–6. Findings revealed a low risk of developing cancer based on these results; however, this assessment is likely to reveal lower concentrations compared to past decades.

Cao et al. (2022) studied the priority control pollutants and hotspots of heavy metals (HMs) contamination of the Yuqiao Reservoir (YQR) in Tianjin, northern China. The authors investigated As, Cd, Cr, Cu, Hg, Ni, Pb and Zn. According to geoaccumulation index (Igeo) and enrichment factor (EF) values, Cd, Cr, Pb and As showed a big enrichment. The multivariate statistics showed that Cd, Cr, Cu, As, Ni, Pb and Zn concentrations were mainly affected by human activities, whereas Hg was mainly from natural release. The potential ecological risk index (PERI) values indicated that 65,7% of total HMs were at low risk, 22,5% in moderate risk and 11,8% in considerable risk. Cadmium should be listed as a priority control pollutant. Spatial maps of HMs and their integrated PERI provided hotspots that indicated lower risk in the region close to YQR but higher risk in the region far from YQR.

Shetaya et al. (2022) assessed the origins, mobility, bioavailability and health risks of V, Cr, Co, As, Se, Mo, Cd, Sn and Sb in some Egyptian environments. The authors used the chemical fractionation, plants uptake, mathematical modelling and risk assessment approaches on soils and plants from industrial, urban and agricultural locations across Egypt. The contents of As, Cd, Sn and Sb were elevated in the soils of some urban and industrial locations within Cairo, although their Igeo indices remained ≤ 2. Igeo for Se was ≤ 4,7 and Sb Igeo = 7,1. In one industrial location. Both principal component analysis and sequential extraction suggested that V, Cr and Co are mostly of geogenic origin, while Se and Sb appear to be of anthropogenic inputs. The most bioavailable element was Cd, that together Mo, is uptake by plants. Risk assessment models showed a low non-carcinogenic and carcinogenic risks to the population of Egypt.

Iqbal et al. (2022) investigated the hydrogeochemical behaviour of groundwater quality attributes including As and their spatial distribution, health risk assessment and public perception of groundwater in Bahawal, Punjab, Pakistan. Groundwater attributes of this study include EC, TDS, HCO_3 PO_4, SO_4, NO_3 and Cl- concentrations, which were higher than the WHO guideline values, whereas none of the water samples showed As concentrations higher than the WHO limit of 10 µg/L. The hazard index (HQ) values for As were less than 1, and there was no apparent non-carcinogenic risk from the consumption of As contaminated water. The questionnaire survey indicated that 82% respondents believe that drinking water quality affects human health and 55% considered that groundwater in the area is not suitable for drinking. They think that the SO_4 containing minerals could be releasing As.

Zhou et al. (2022) researched the distribution characteristics and potential ecological risk assessment on heavy metals (HM) in soils around Shannan landfill site, Tibet. In the study, the geoaccumulation index method, Nemerow comprehensive pollution index method and potential ecological risk index method are used to evaluate the pollution and risk of HM in the soil around the landfill site. The main results are: the pH of the soil around the landfill is 9.37. The values of Hg and Ni in soil exceeded the background content, and the content of the Cu, Pb, Zn, Cr, As and Cd not exceeded it. The geoaccumulation index shows that Hg is the most affected. The pollution index is moderate, between 2 and 3. The west side of the landfill is greatly affected. The total potential risk coefficient belongs to medium pollution hazard level. There is no significant correlation between As and Hg and the other 6 HM. The pollution source of As is

due soil forming factors and the source of Hg is due human factors.

Lam et al. (2022) assessed the potential risk due to the presence of metals and metalloids in soil affected by four oil spill events at Playa Las Petroleras, Antofagasta, Chile. The concentrations of 15 elements in soil samples were analysed, four of them presenting potential ecological risk: As, Co, Cu and Pb. Nine pollution indices were applied to data: four single pollution indices and five integrated pollution indices to assess soil pollution. The single pollution indices show that the site bears potential ecological and environmental risk due to the presence of Cu, the site being classified as highly contaminated owing to a severe enrichment of this metal. For Co, all the indices allow classifying the site as low contaminated. The level of As and Pb pollution ranked as moderate contamination. The integrated values of these four elements, when applying these indices to the mean and maximum concentrations show high contamination in all indices. Only the Modified Degree of Contamination (mCd) and Potential Ecological Risk indices differentiate the degree of contamination from mean to maximum values in the results.

Ataabadi et al. (2022) investigated the Cr^{6+} bio removal from contaminated wastewater using *Pseudomonas aeruginosa* ATHA23 producing biofilm supported on clinoptilolite. Preparation of clinoptilolite, bacterial grown and isolation, biofilm production including extracellular polysaccharides (EPS) and Cr^{6+} removal efficiency, affected by the experimental treatments were investigated. The use of FTIR characterized clinoptilolite properties with and without biofilm in the presence and absence of Cr^{6+}. Plackett–Burman and Taguchi statistical analyses were used to optimize the experimental treatments affecting the removal efficiency of Cr^{6+}. The data of adsorption by clinoptilolite-biofilm was better fitted to Freundlich isotherm model. The Cr^{6+} bioremediation potential of *P. aeruginosa* ATHA23 by the production of biofilm supported on clinoptilolite has been shown for the first time.

Singla et al. (2022) studied the concentration of radon in fifty samples of drinking waters of Hanumangarh District of Rajasthan, India, and the assessment of resulting dose to local population. The authors measured the concentration of dissolved radon using scintillation-based Smart RnDuo detector and the standard protocol recommended by BARC. 33 of the analysed samples were from surface water sources and 17 samples were from groundwater sources. The concentration of radon in surface water varied from 0.12 Bq/l to 2.07 Bq/l with an average value of 0.62 Bq/l. The measured values were well below the safety limits recommended by WHO 2008. The results were discussed in context of the nature of water source, aquifer characteristics and geology of the district. The ingestion and inhalation dose were to assess the health risk for infants, children and adults. The authors concluded that radon in water does not pose a significant radiological health risk for the population of the studied area.

Liu et al. (2022) investigated the environmental impacts of 222Rn, Hg and CO_2 emissions from the main active fault zones in the western margin of the Ordos block, China. Most of the major fault zones at the study area are CO_2 risk-free regions (CO_2 concentration in soil gas < 5%). However, the extent of 222Rn pollution zones of F1, F2, F5 and F9 and that of Hg pollution at the fault zones of f2, F4, F5 and F7 were higher than the pollution level of 1. Comprehensive analyses indicated that the higher emission rates of soil gases from the active fault zones were related to the seismic activities. The strong seismic activities in this region may be the dominant impact factor causing the high emissions of 222Rn, Hg and CO_2 from the main active fault zones in the western margin of the Ordos block.

Luo et al. (2022) proposed a method of assessing the depth of contaminated sediments that should be removed in lakes: a case study of Tangxun Lake, Hubei Province, China. The authors used organic index method, pollution index method and potential ecological risk evaluation to assess the contamination status of split samples of in situ sediments layer-by-layer and stablished a comprehensive contamination index evaluation method for layer-by-layer sediments, then combined with the contamination release characteristics of split samples to assess the contamination degree of the sediments obtained. The results show that the content of N and P in the surface layer of sediments is higher than that in the middle and bottom sediments, and the HM also satisfies this pattern, which is consistent in the sediments of both eastern and western regions. This method provides a scientific basis for sediment dredging in Tangxun Lake and provides a new paradigm for sediment dredging depth estimation in similar lakes.

Ambade et al. (2022) studied the distribution, risk assessment and source apportionment of PAHs using positive matrix factorization (PMF) in 40 urban soils collected from two industrialized cities, Jamshedpur (JSR) and Bokaro (BKR) in East India. The results showed the predominance of high molecular weight (HMW) PAHs (4–5 rings). The total concentration of PAHs in soils of JSR and BKR cities ranged from 2223 ng/g to 11,265 ng/g and 729 ng/g to 5358 ng/g (dw), respectively. The higher concentrations of PAHs were recorded at the industrial belts of the two cities. The HMW PAHs were dominant in urban soils. The soils of JSR city were more polluted than BKR city. The diagnostic and PMF analysis indicated that the chief origin of PAH contamination was petroleum combustion, vehicular emissions and coal combustion. The health risk study implies that the JSR city adults have a higher carcinogenic risk than BKR city.

Hussain et al. (2022) explored the impact of various ameliorants on geochemical As distribution in two soils in contrasting textures (sandy clay loam, Khudpur village, and clay loam, Mattital village) under paddy soil conditions, and their influence on the CO_2-carbon efflux. The exchangeable As pool in clay loam soil increased as: lignite (0.4%) < biogas slurry (6%) and biochar (20%). However, in the sandy clay loam exchangeable soil As pool was found to be maximum with farmyard manure followed by biogas slurry, biochar and cow dung (17%, 14%, 13% and 7%, respectively). In the sandy clay loam soil, the percentage As distribution in organic fraction was: biochar (38%) > cow dung (33%) > biogas slurry (23%) sugarcane bagasse (22%) > farmyard manure (21%), that was higher compared to the clay loam soil for all the amendments.

Conclusions

The content of this Special Issue is of great importance and the 18 papers cover significant aspects of fundamental theoretical and applied research in geochemistry, soil contamination and human health and providing advances to the existing knowledge.

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Conflict of interest The author has not disclosed any competing interests.

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