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PREFACE

Special issue on "geochemistry, soil contamination and human health. Part 1"

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Background

The 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 in 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 has 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 a number of 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. To solve these problems, it is necessary to concertedly interpret geochemical and medical information in order to assess the risks to human health associated with modern natural and anthropogenic geochemical features in urban and rural habitats.

This special issue contains 20 papers written by authors from 11 countries: Chile, China, Cyprus, India, Iran, Nigeria, Pakistan, Russian Federation, Spain, Tunisia and Turkey.

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

Duan et al. (2021) investigated HMs' accumulation and risk assessment in a soil–maize system around a Zn smelting area from Magu Town, Guizhou Province, Southwest China. The concentrations of Pb, Cd, Cu and Zn in soil exceeded their corresponding background and standard values in Guizhou, China, respectively. Also, the concentration in the maize grain exceeded the maximum permissible limits, in decreasing order Zn > Pb > Cu > Cd. Bio-accumulation values were in the rank Cd > 1 > Zn > Pb > Cu. The results of translocation factor and Fourier

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transform infrared spectroscopy demonstrated that the maize root acts as a barrier against the mobilization of HMs to stem, except for Zn. From the results of both spatial interpolation analysis and correlation, the authors concluded that the high homology existed between Pb, Cd, Cu and Zn in soil and grain, respectively. Although the mean hazard quotient and the total hazard index values were below the safety level (HQ = 1), it implies no potential non-carcinogenic risk for local maize consumers.

Ediagbonya and Ajayl (2021) examined the occurrence of elements in a polluted soil (Okitipupa, Nigeria) due to oil spill, rusting iron and proximity to a dumpsite and also to identify the soil contamination level via enrichment factor (EF) and contamination factor/pollution index. Soil samples were investigated using X-ray fluorescence. The enrichment value was computed using Ti, Mn, Zn, Cu, Cr and Fe as reference elements. Sc was not found at the hospital dumpsite, while As was not found at a market place. The pollution index value is shown in this order: Ni > Fe > Cu > Cr > Zn > Mn > As and the enrichment value in this order: Ni > Se > Cu > V > Zn > Cr > Zr > As > Mn > K > Ca > Rb > Ti > Sr when Fe was used as a reference element. The overall risk index in all the locations in the soil was above the limit.

Dhanapal et al. (2021) researched on the molecular response of DNA repair, UV resistance and As-resistant genes of a *Deinococcus indicus* MTCC 4913^{T}. Gene expression studies in response to various extreme environmental stresses like UV and heavy metals evidenced the withstanding and recovery mechanism possessed by *D. indicus* to maintain its genome stability. Moreover, the putative length, molecular weight, conserved domains, signal peptides, secretary nature, glycosylation pattern and GPI anchor sites in these genes were determined using *in silico* tools. Gene expression analysis showed a differential expression pattern where most of them were highly responsive to UV and heavy metal stresses, indicating their critical roles. These results enabled the investigators to put forward *D. indicus* as a promising candidate for functional genomic analysis which could help formulate strategies for drug development and bioremediation applications.

Barhoumi et al. (2021) studied the mineralogical, thermal and rheological characterization of three Tunisian green commercial clays and explored the possible application as peloids with thermal and sea waters. The authors investigated the green clays of the regions of Douiret (CD), Tozeur (CT) and Korbous (CK) in terms of their physico-chemical structure, chemical composition, heavy metals risk assessment, thermal properties, plasticity, rheology and their potential application as peloid with distillet and sodium chloride-rich sulphated thermal waters from hot spring in the region of Lif and Korbous and sea water. The mineralogy was determined by X-ray diffraction and FTIR analysis, while the chemical composition by ICP. The main clay fraction was smectite and illite with the presence of kaolinite. The samples rich in smectite are more suitable for use in Tunisian spas and for the application as peloids.

Bineshpour et al. (2021) studied the status, source, human health risk assessment of potential toxic elements (PTEs) and Pb isotope characteristics in urban surface soil of the Arak City, Iran. The results show that the main components of Pb, Cr and Zn at most of the sampling sites are Fe–Mn bound/reducible. The residual fraction is the dominant fraction for Ni, Cu and Zn. Statistical analysis, enrichment factor, enrichment index and top enrichment factor confirm that Pb, Ni, Cu, Cr, Cd and Zn had a similar anthropogenic source. Carcinogenic risks (CR) of studied PTEs were estimated to be higher than the target limit of 1.0E-06, for adults and children except for Cr with values of 5.91E-04 and 3.81E-04 for children and adults, respectively. Higher CR values of Cr compared to other PTEs in Arak surface soil demonstrate that living target populations, particularly children, are at more carcinogenic risk of PTEs.

Kobya et al. (2021) studied the concentration of As, Co, Cr, Cu, Mn, Ni, Pb and Zn of soils of metallogenic belt from Artvin Province, NE Turkey, using pollution and health indices. Results showed for the soils the enrichment factor (EF), geo-accumulation index (I_{geo}) and contamination factor (CF) severe enrichment, moderately polluted and very highly contaminated with As, respectively. The pollution load index score (1.57) indicates that these Artvin's soils are polluted in the aforementioned trace elements. The hazard index (HI) values for children and adults were 1.55 and 0.18, respectively. The non-carcinogenic risk level indicates that there may be a risk for children rather than adults.

Fernández-Gómez et al., (2021) performed a laboratory-scale experiment to determine the effectiveness of oxygen-saturated seawater injections (OSSWI) and air sparging (AS) technologies in remediation of coastal marine sediments from sludge. The results showed that both technologies significantly increased dissolved oxygen content in pore water, facilitating the oxidation of more than 90% of the organic matter, and other reduced inorganic compounds such as sulphide. After 65 days, soft, black, muddy and hypoxic sediment with low organic matter content is obtained and has lost its initial shiny black colour and odour. OSSWI or AS are environmentally friendly technologies, since they avoid loss of coastal sand by enabling remediated, pollution-free sediments to be deposited along the coast.

Kolmykova et al. (2021) investigated the chemical composition of groundwater used for drinking in conditions of natural deficiency of I and Se, and evaluation of the health effect: the case of Bryansk region, Russia. Groundwater samples (*n* = 515) were collected in 156 rural settlements over the region in the period from 2007 to 2017 and analysed for catiogenic elements (Ca, Mg, Sr, k, Na, Mn, Zn, Fe, Al, Si) and anions (HCO_3^-, Cl^-, F^-, SO_4^{2-}, NO_3^-, PO_4^{3-}) as well for I^- and Se using ICP-AES, potentiometry, photometry and spectrofluorimetry. The results confirmed a low supply of water samples with I (median, Me = 5.96 μg L^{-1}, variation range 0.06–41.2 μg L^{-1}) and Se (Me = 0.18 μg L^{-1}, variation 0.001–0.21 μg L^{-1}). The data on chemical composition of drinking water were analysed for correlation with the medical data on the prevalence of endemic thyroid diseases among the population living in the corresponding rural settlements. Incidence of thyroid diseases and I deficiencies among teenagers aged 8 to 12 has been found.

Rani et al. (2021) carried out the radiological risk assessment to the public due to the presence of radon isotopes in drinking water of Barnala District, Punjab, India. The authors for the first time used a SMART RnDuo scintillation-based detector. A total of 100 samples were collected from different sources of water from 25 villages on grid pattern of 6 × 6 Km^2. Results showed that the values of ^{222}Rn have been found to vary from 0.17 to 9.84 BqL^{-1} with an average value of 3.37 BqL^{-1}, that is, below 4–40 BqL^{-1} by UNSCEAR, 2008. As the measured values in the studied area are below the recommended safe limits, it can be concluded that radon in water may not pose any significant radiological risk to the public.

Amir et al. (2021) assessed the levels of As in drinking water, vegetables, irrigation water, agricultural soils and the human population of rural and peri-urban areas of Multan (Pakistan). The authors for a comparison between peri-urban (exposed site) and rural areas (control site) sampled irrigation water, vegetables and vegetable-grown soils, drinking water, and human blood. In all samples, As concentration was significantly higher at the exposed site than at the control site. Among the studied vegetables, the cumulative daily dietary intake of As was recorded maximum by the consumption of okra on exposed site. As intake via drinking water was estimated to contribute $> 98\%$ of total As intake at both sites, the health risks associated with drinking As-contaminated groundwater were much higher than the health risks due to the consumption of As-contaminated vegetables. Blood As levels in the most of the subjects at exposed site exceeded the safe limit of 12 μg L^{-1}.

Natasha et al. (2021) investigated the role of soil microbes (SMs) and sulphate in reducing As phytoaccumulation and phytotoxicity using *Zea mays* L. as a test plant, under varying sulphate levels (S-0, S-5, S-25 mmol Kg^{-1}) and As stress. Results showed that SMs-S-5 treatment proved to be the most promising in reducing As uptake by 27% and 48% in root and shoot of the maize plants, respectively. Overall, the SMs-S-5-treated plants possessed improved plant growth, dry biomass, physiology and antioxidant defence system and a decrease in plant shoot As concentration. The outcomes of this research suggest that sulphate supplementation in soil along with SMs could assist in reducing As accumulation by maize plants, providing a sustainable and eco-friendly bioremediation strategy in limiting As exposure.

Baragaño Coto et al., (2021) estimated a comparison of the effectiveness of biochar vs magnesite amendments to immobilize metals and restore a polluted soil. The authors used 1-kg pots containing a polluted soil with Cd, Cu, Pb and Zn, amended with either magnesite or biochar mixed with compost and then determined metal availability and soil properties at days 15 and 75. Moreover, to evaluate the impact of the two treatments on plant growth, the trials were carried out using *Brassica juncea* L. Both amendments, particularly magnesite, decrease the metal availability. However, plant growth was inhibited by magnesite. In contrast, biochar increased the biomass production, whereas decreased the content of metals harvested.

Rodriguez-Espinosa et al. (2021) carried out a bibliographic review about the quality of urban soils, human health and Technosols for the Green Deal. The authors in this review found that healthy soils might preserve human health and urban healthy soils may provide equal or more benefits than natural soils. The amount of carbon stored by green urban areas seems to be associated mainly with their size. For greening plans, consulted authors propose brownfield regeneration since they are able to provide ecosystem services. The introduction of new green areas might lead to an increase in required water and soil resources for plant maintenance. Further research might explore quantity and quality of water for hosting the new urban natural landscape and also propose the use of waste from human activity for generating urban Technosols. The ecosystem benefits of constructed Technosols are not expressly approached through the prism of human health.

Long et al. (2021) investigated the effect of urea feeding on transforming and migrating soil fluorine in a tea garden of hilly region of western Sichuan, China. The authors simulated the local climate, especially the natural precipitation through column leaching experiment to evaluate the effect of fertilization on F desorption from soil. The results indicate only urea and promote the dissolution of F from soil. To reveal the effect of urea on migration of F from soil to tea, field plots experiment in a tea garden was carried out. The results showed that urea promoted soil acidification continuously, due to an increase in dissolved F and Al content in soil, which migrated to tea as F–Al complex.

Buzmakov et al., (2021) studied in a model laboratory experiment the effect of oil pollution in the main soils of coniferous–deciduous forests and forest steppe, Solovetsky oil field, Perm region, Russia. This experimental method made it possible to assess the impact of oil pollution in various types of soils on microbial and plant test organisms, to assess the impact on aquatic organisms and to calculate the level of predicted risk for humans. The studied soils can be arranged in the following descending order of the negative impact of oil pollution on organisms: Luvic Phaeozems > Albic luvisols/Retisols > Calcaric Leptosols > Greyzamic Phaeozems > Folic Fluvisols. The most sensitive test organism for all types of soils was the inhibition of the development of the roots of plant seedlings. Oil addition at 5 g oil/Kg of soil increases the level of carcinogenic risk to children to the threshold values of acceptable risk.

Barral et al. (2021) researched the hydrochemical evolution of the Reocin mine filling water, in Cantabria, Northern Spain. The mine exploitation, dedicated mainly to extraction of sphalerite and galena, ended in 2003. In 2004, the controlled flooding of the open pit began. This study focuses on the lake water chemistry analysis of the pit lake surface. The water quality continues improving. The sulphate content and Zn concentrations are already below the permitted pouring limits. The water supply from the aquifer contributes to the dissolution of the salt content and the limestone and dolomite which neutralizes acid waters, precipitating Fe and other metals, and improves the water quality using the flooding process with a pH value of 8. The filling of the pit lake provides the opportunities to use it.

Huina et al. (2021) analysed the chemical forms and characteristics of heavy metals (HMs) in road dust collected from 15 sampling sites in Zhengzhou (China). Based on the bio-toxicity of different fractions of the HMs and Monte Carlo, three assessment models, including the health risk assessment based on bio-toxicity, the health risk assessment based on the Monte Carlo simulation and the health risk assessment based on the Monte Carlo simulation and bio-toxicity, were established. Among different HMs, the non-carcinogenic risks of As were the highest and the carcinogenic risks of Cr were the highest, so As and Cr should be listed as priority control contamination. MB Traditional model established in this study simultaneously considered bio-toxicity and random simulation obtained more accurate results.

Agahjari et al., (2021) investigate the mineralogy, geochemistry and ^{13}C and ^{16}O isotopic characteristics of urinary stones in Lorestan Province, Iran. The authors using X-ray diffraction and SEM found five groups of calcium oxalate, urate, cysteine, phosphate and mixed stones (whewellite, uric acid, phosphate). SEM studies revealed that whewellite was the most important mineral phase. Major and rare elements of each group were determined by ICP-MS and X-ray fluorescence analysis. Ca was found the most abundant element in urinary stones. CaO had the highest frequency in urinary stones. The average values of isotopes ^{13}C and ^{16}O in the studied urinary stones were obtained − 33.71 and − 20.57, respectively. Overall, the values of ^{13}C isotope in urinary stones were lower than those in the similar stones in other countries.

Liu et al. (2021) have evaluated the accumulation risk and source apportionment of heavy metals in different types of farmlands in a typical farming area of northern China. In this study, a total of 252 soil samples were taken from dry land, paddy fields and greenhouse fields in the Jinyan District of Taiyuan City, China, to assess the accumulation risk of As, Cd, Cr, Cu, Hg, Ni, Pb and Zn. Soil pollution by Cd and Cu was more severe in greenhouse fields than in dry land or paddy fields, whereas As, Hg and Pb had relatively higher levels in paddy fields than in dry land or greenhouse fields. Source apportionment by geospatial analysis, multivariate statistical analysis and PMF modelling showed that Hg originated mainly from coal combustible. A considerable portion of Cu, Ni and Zn in paddy fields was derived from sewage irrigation. In greenhouse fields, fertilization is likely the dominant source of heavy metals in the soil, especially Cd.

Ahmad et al. (2021) investigated the hydrogeochemical and health risk of As, Cd, Cu and Mn in groundwater along the River Sutlej floodplain in Punjab (Pakistan). Results showed that groundwater used for drinking by people contained high concentrations of As and Cd, exceeding the WHO safe limits. The other water quality attributes such as EC, HCO_3^-, Cl^- and SO_4^{2-} were also found above their safe limits in most of the wells. Hydrogeochemical data indicate saline water. The hazard quotient and cancer risk indices calculated for As and Cd indicated potential threat (carcinogenic risk > 0.0001 and non-carcinogenic risk > 1) of drinking groundwater investigated. Therefore, it is important to monitor groundwater quality in the adjacent areas along River Sutlej floodplain and initiate suitable mitigation and remediation programmes for the safety of people's health in Punjab, Pakistan.

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 geochemistry, soil contamination and human health, providing advances to the existing knowledge.

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