# MEDGEO 25 ISEG

11th International Conference on Medical Geology

&

13th International Symposium on Environmental Geochemistry

# Book of abstracts

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# preface

# WELCOME TO THE 11th International Conference on Medical Geology & 13th International Symposium on Environmental Geochemistry – MEDGEO25ISEG

Dear Participants,

On behalf of the scientific and Organizing Committees, we welcome you to the 11th International Conference on Medical Geology and the 13th International Symposium on Environmental Geochemistry - MEDGEO25ISEG. We are honoured to host this prestigious event focusing on "Challenges and Solutions to Promote Earth Sustainability and Human Health."

This conference is proudly supported by the University of Aveiro, the GeoBioTec Research Centre, and the International Medical Geology Association (IMGA). Together, we aim to foster dynamic exchange among scientists, researchers, and professionals from across disciplines who are united by a common goal: understanding and addressing the complex interplay between environmental factors and human health.

MEDGEO25ISEG brings together over 150 researchers from 17 countries, reflecting the growing global relevance of medical geology and environmental geochemistry in science, policy, and education. This multidisciplinary gathering features a vibrant program that spans geochemistry, geology, biology, hydrology, engineering, toxicology, epidemiology, chemistry, medicine, and nutrition.

Our four-day program is designed to spark insightful discussions and promote cross-sectoral collaboration. It includes sessions on:

- Trace elements and radionuclides in the environment
- Organic and emerging pollutants
- Geochemical mapping, human health impacts, and environmental remediation
- Urban geochemistry, waste management, and quality of life
- Toxicological and epidemiological impacts on human health
- Geological materials in health and well-being
- Advances in analytical methods and techniques
- Perception and communication of environmental hazards and health risks
- Special Session 1: Geo-Health: Present and Future

We proudly present a diverse scientific program comprising 7 Plenary Conferences, 64 oral presentations across two parallel sessions, and 46 poster presentations, showcasing the latest research developments in the field. The Book of Abstracts, featuring one-page summaries of all accepted contributions, is a valuable guide to the innovations and ideas shared at the conference.

To enrich your experience further, a post-conference technical field trip has been arranged to explore the region's thermal/SPA facilities. This trip offers a practical and relaxing conclusion to the scientific program.

We also warmly welcome you to Aveiro, a city shaped by its stunning "Ria de Aveiro" lagoon. Known as the "Venice of Portugal," Aveiro is a unique blend of natural beauty, tradition, and modern flair—a perfect setting for scientific inspiration and cultural enjoyment.

Our deepest thanks go to the Scientific Committee for their meticulous review of submissions and to the administrative staff at the University of Aveiro for their invaluable support. We also sincerely thank GeoBioTec Research Centre, SPHM, Soquimica, LECO, Termas de Chaves, Pedras Salgadas Park, and Centro Interpretativo da Mina de Jales for their generous contributions.

Special appreciation is extended to all members of the Organizing Committee for their dedication, and to Prof. Álvaro de Sousa for his creative design work, which has brought this conference to life visually.

We wish you an enriching, enjoyable, and productive stay in Aveiro. May MEDGEO25ISEG catalyse new collaborations, revitalized friendships, and lasting contributions to our shared mission of advancing human and planetary health.

Welcome—and please, feel at home!

**Eduardo Ferreira da Silva | Chaosheng Zhang**
**(MEDGEO25ISEG Chair | IMGA and ISEG Chair)**

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# Tribute to Olle Selinus

We are delighted to dedicate the 11th International Conference on Medical Geology (MEDGEO2025) to Dr. Olle Selinus.

Olle's most significant contribution to the international scientific community was the development of the discipline of "Medical Geology". He also co-led the establishment of the International Medical Geology Association (IMGA) in 2006. Another significant contribution by Olle was the establishment of the International Symposium on Environmental Geochemistry (ISEG) conference series, which started with an initial local symposium on environmental geochemistry held in Kuopio, Finland in 1985. Olle's many scientific contributions focused not only on medical geology but also on applied geochemistry, the use of geochemical methods and geostatistics in mineral exploration. He published more than one hundred scientific articles, was an editor of several highly acclaimed books in English and Swedish. Among the several books he has produced are the multiple award-winning "Essentials of Medical Geology" (2005), "Medical Geology – a Regional Synthesis" (2010), and his latest book, "Practical Applications of Medical Geology" (2021). Olle Selinus was a tireless worker dedicated to advancing the science of Medical Geology and protecting human welfare. Olle will be remembered as dedicated mentor of many young geoscientists and geochemists in their careers, who are now the leading figures in medical geology science. He was active in promoting medical geology right up to his passing in 2023.

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# plenary conferences

# The Emerging Scientific Discipline of Medical Geology – Its Origin, Recent Advances and Future

Jose A. Centeno

University of Puerto Rico at Mayaguez, Department of Chemistry. 6V75+3M8, PR-108, Mayagüez, 00680, Porto Rico
University of Maryland School of Medicine Division of Occupational and Environmental Medicine, 655 W. Baltimore Street Baltimore, MD 21201. USA

## Abstract

Medical Geology is defined as the study of the impacts of geologic materials and geologic processes on animal and human health. Over the past 20 years Medical Geology has developed into a mature discipline with numerous adherents. Several international and national associations emerged devoted fully or partially to this new scientific discipline. Numerous books on the subject have appeared in this time, as well as dozens of short courses, workshops, lectures, journals, and countless journal articles. International, national and local conferences have been devoted to this topic. This presentation will emphasize the global impact of this discipline with particular attention to its origin, its recent advances and its future.

**Keywords**: Medical Geology; Human health; Dust; Toxic trace elements

# The role of medical geology in understanding the causes of non-communicable diseases (NCDs) and achieving the United Nations Sustainable Development Goals (UN SDGs) in Africa

Hassina Mouri

[1]UNESCO Chair in Medical Geology in Africa; Department of Geology, University of Johannesburg, Republic of South Africa

**Abstract**

The African continent faces a high mortality rate from non-communicable diseases (NCDs) such as cardiovascular diseases, chronic respiratory conditions, cancer, and diabetes, according to WHO reports. These diseases account for over 50% of deaths in several African countries. Furthermore, globally, Africa continues to hold the highest neonatal mortality rate and the greatest burden of maternal mortality. The prevalence of these diseases affects the socio-economic development of the region and hinders the achievement of the UN's Sustainable Development Goals. Unfortunately, the primary causes of these diseases and their related mortality often remain unclear, as more attention is typically given to their risk factors and treatments.

From a geological perspective, the African continent has a complex and dynamic geological history characterised by frequent earthquakes and volcanic eruptions in tectonically active regions. Furthermore, water toxicity resulting from interactions with the geological environment, including rocks and soil, as well as air pollution from dust storms, especially in the continent's arid regions, represents one of the most common issues faced. Moreover, the continent is well-known for its extensive mining operations and oil and gas exploration, which lead to an increase in the release of chemical elements and inhalable nanoparticles of minerals into the environment.

The question is whether these geo-environmental factors and materials contribute to the occurrence and worsening of such common NCDs on the continent.

Medical geology is a science field vital for addressing this question and exploring potential connections between geo-environmental and health challenges.

Furthermore, research in this field can provide solutions and mitigation measures while advancing several UN Sustainable Development Goals (SDGs) through collaboration with experts from various scientific disciplines. This involves identifying geological sources of toxic and potentially harmful elements in the environment and the minerals that are transferred to humans and animals through food, water, and air, as well as pinpointing areas that lack essential elements necessary for healthy living. These efforts are crucial for mitigating the health impacts caused by such anomalies and ensuring well-being, which is one of the key UN Sustainable Development Goals (SDGs). The identification of geo-anomalies and their associated health issues is followed by the development and application of predictive geospatial distribution modeling and techniques for their removal.

Furthermore, to mitigate health risks related to toxic and potentially harmful elements and minerals, it is essential to assess the nature and composition of the water and energy sources used for daily consumption. The continent's growing population is driving the increasing demand for safe and adequate water and energy. As a result, communities, especially in rural areas, often depend on unsafe alternatives, like unregulated water sources and burning coal for daily needs, which may have high levels of toxic and potentially harmful elements and minerals. Naturally occurring hidden chemical elements and minerals can have serious short-term and long-term health effects.

Therefore, evaluating these substances is essential to prevent health damage and promote a safer living environment for communities. Furthermore, training postgraduate students in medical geology to understand the geo-environment and its health impacts on humans, animals, and ecosystems is a key priority in Africa.

# Cerro de Pasco: From Acid Mine Drainage to a Model of Sustainable Mining

Bernhard Dold

University of Luleå (LTU), Sweden; Pontifical Catholic University of Peru (PUCP); Cerro de Pasco Resources Inc. (CDPR), Canada; H2-SPHERE GmbH, Germany.

## Abstract

The Cerro de Pasco mine in Peru stands as a striking example of the environmental challenges associated with prolonged mining activity. The region's polymetallic deposits have been exploited for centuries, resulting in significant environmental degradation, including widespread acid mine drainage (AMD) and contamination. However, recent initiatives aim to transform this legacy into a model for sustainable mining practices.

A geochemical and mineralogical investigation of the Quiulacocha tailings impoundment has highlighted the critical role of hydrological connectivity within the mine-waste system at Cerro de Pasco in controlling AMD and managing mine waste effectively. The Quiulacocha tailings, covering approximately 114 hectares and comprising around 70 million tonnes of material, contain about 50 wt.% pyrite. These tailings are located at an altitude of 4,340 meters in a tropical puna climate, characterized by an average annual rainfall of 1,025 mm and evaporation of 988 mm.

Partially overlying these tailings is the Excelsior waste-rock dump, which spans 94 hectares and contains approximately 26.4 million cubic meters of waste rock with around 60 wt.% pyrite. The hydrological connection between the Excelsior and Quiulacocha deposits has facilitated the transport of AMD from Excelsior into the Quiulacocha tailings, resulting in significant leaching. This process has altered the geochemical environment, transforming originally dolomite-hosted Pb-Zn tailings (pH 8.5) into siderite-buffered tailings (pH 5.5).

To address the environmental challenges at Cerro de Pasco, CDPR has initiated a reprocessing strategy targeting historical tailings for the recovery of valuable metals, including zinc, copper, lead, silver, and gold. This approach serves both as a remediation measure and as a step towards resource recovery. Notably, these historical tailings often contain higher metal concentrations than some modern primary ores. As such, they are increasingly regarded as resources rather than waste and are now also being explored for critical elements that were previously overlooked. This initiative aligns with circular economy principles, aiming for zero waste and long-term sustainability in mining operations.

In a pioneering development, H2-SPHERE GmbH, in collaboration with the German Aerospace Center (DLR), is advancing technology to convert pyrite-rich mine waste into green hydrogen. At industrial scale, this process could repurpose pyrite—historically seen as a problematic source of AMD—into a valuable feedstock for producing green fertilizers, including ammonium and sulfuric acid. In this context, pyrite may be reimagined from "fool's gold" into the "gold of the wise."

The transformation of Cerro de Pasco from a site of severe environmental degradation into a model for sustainable mining underscores the potential of innovative technologies and collaborative approaches. The concerted efforts of academia, industry, and local communities demonstrate the viability of implementing sustainable mining solutions even in historically challenging environments.

# Environmental remediation of mining legacy sites in Portugal

Catarina Diamantino

EDM – Empresa de Desenvolvimento Mineiro S.A.

## Abstract

Environmental remediation of legacy mining sites in Portugal has been done since 2001 by EDM - Empresa de Desenvolvimento Mineiro, a State-owned company that has been granted the responsibility for the environmental remediation of all mining legacy sites in Portugal, under a concession contract established by Decree-Law 198-A/2001. The implementation of remediation aims for the reduction of risks to people and to the environment resulting from water pollution, soil contamination, heaps and unprotected areas, and to contribute to the reuse of these areas for different beneficial end-uses, through the restoration of landscapes and habitats. In the scope of the concession contract are included 199 legacy mining sites, including 62 radium and uranium sites and 137 polymetallic mines. Since the beginning of the concession, 117 mining sites have been remediated (53 of which were radioactive mines), and 10 radioactive and polymetallic mining sites are planned for remediation by 2030. These results were achieved through a clear remediation strategy, as well as a comprehensive set of characterization studies, plans, and detailed projects. Additionally, a pre- and post-remediation environmental monitoring and maintenance plan is ongoing, which includes the operation of several mine water treatment plants. This presentation briefly describes the model and strategy adopted by EDM for environmental remediation, as well as the most representative solutions for confining mine wastes, controlling and treating mine water, including some examples of major interventions at the Urgeiriça and Lousal mining sites..

# Soil Ecology and Ecotoxicology on the broad concept of Soil Health

Ruth Pereira

GreenUPorto/INOV4Agro & Department of Biology of the Faculty of Sciences, University of Porto, Portugal

## Abstract

In the realm of the new directive on soil monitoring and resilience (DSMR), under approval, reflection on the use of soil biological indicators/soil ecotoxicology tests and related methods must continue, to convince regulators of its relevance. Few biological indicators were included in the list of mandatory descriptors, despite others being suggested as optional, leaving their selection under the responsibility of European Member States. Variability in their response, the interference of many confounding factors and the costs of evaluation are, in fact, the reasons for not being selected. Regarding ecotoxicological tests they were lost in the process, because while they are still recommended for risk assessment frameworks, they were excluded from soil health evaluation. But in fact, they can provide relevant information on soil health functions, and, since they are performed under controlled conditions, they can also be a valuable tool to overcome some of the difficulties highlighted above.

The reliability of soil biological indicators and their ability to respond to changes in soil health require more scientific evidence, and living labs are envisioned as an opportunity for collecting the necessary data. However, experimentation in real-life settings also brings some challenges that need to be carefully analyzed. This communication aims to discuss the challenges of this topic, drawing on evidence from some illustrative results gathered in various projects.

# Natural Mineral Waters and Health Effects

Pedro Cantista
University of Porto – School of Medicine and Biomedical Sciences

## Abstract

Thermalism is, in its genesis and development, a health phenomenon. Present in the activities of human societies throughout all eras, the therapeutic use of mineral waters must prevail. How this happens will depend on the correct strategies of decision-makers, which must be based on rigorous scientific criteria. Based on scientific research in the field of Hydrology and Thermal Medicine and taking into account the aforementioned vision we outlined for the evolution of health in the coming decades, we present a set of reflections on the paths that thermalism and thermal resorts must follow to adapt to the new times, better serve their users and lead to models of sustainable development.

# The silent risks of dormant volcanoes: respiratory health hazards

Patrícia Garcia[1,2], Ricardo Camarinho[1,3], A. Rodrigues[1,3]

[1]FCT, Faculty of Sciences and Technology, University of the Azores, 9501-801 Ponta Delgada, Portugal
[2]cE3c—Centre for Ecology, Evolution and Environmental Changes & CHANGE—Global Change and Sustainability Institute/Azorean Biodiversity Group (cE3c-ABG), University of the Azores, 9501-801 Ponta Delgada, Portugal
[3]IVAR, Institute of Volcanology and Risks Assessment, University of the Azores, 9501-801 Ponta Delgada, Portugal

## Abstract

It is estimated that 10% of the worldwide population lives in the vicinity of an active volcano. However, studies on volcanogenic air pollution are still outnumbered when compared with those on anthropogenic air pollution, representing an unknown risk to human populations inhabiting volcanic areas. Present-day volcanic activity in the Azores archipelago is characterised by several hydrothermal manifestations, including active fumarolic fields, thermal and cold CO2 springs, and diffuse degassing areas in the soil. This type of "silent" volcanic activity is responsible for the emission into the environment of several noxious compounds, such as gases (some radioactive, such as radon, other neurotoxic, like gaseous elemental mercury) and heavy metals, which can cause adverse health effects in organisms that live in these areas, including humans. In this presentation, we will unveil some of the silent risks associated with living in these environments by presenting and discussing our most recent studies, which use wild mice as bioindicators to assess the health effects of vulcanogenic pollutants on the respiratory system.

**Keywords**: Non-eruptive volcanism; Volcanogenic pollutants; Biomonitoring; Respiratory system

MEDGEO 25 ISEG

# theme 1

## trace elements and radionuclides in the environment

# Impact of tailings on the environmental quality of stream sediments around the abandoned Azibrais mine (Sn-W), central Portugal

João Silva[1], Eduardo Ferreira da Silva[1], Fernando Rocha[1], Paula C. S. Carvalho[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal.

## Abstract (poster)

Mine dumps are the main source of potential toxic elements for ecosystems in old mining areas. The former Sn-W Azibrais mine, located 10 km from Gouveia town in central Portugal, was active between 1940 and 1950 and produced several abandoned dumps. Tailings reaching the streams through erosion and weathering processes exhibit pH values ranging from acid to neutral (3.6 – 7.2) and maximum concentrations of Cu (1.38%), As (8722 mg $kg^{-1}$), Cd (149 mg $kg^{-1}$), Sn (1814 mg $kg^{-1}$), and W (335 mg $kg^{-1}$). These tailings comprise quartz, muscovite, shattuckite, hisingerite, goethite, siderite, arsenopyrite, and Al- or Fe-hydroxides. Downstream sediments have Cu, As, Cd, Sn and W concentrations ranging from 24 to 630 mg $kg^{-1}$; 165.6 to 3550 mg $kg^{-1}$; 0.28 to 10.9 mg $kg^{-1}$; 27.1 to 1226 mg $kg^{-1}$; and 2.9 to 39.7 mg $kg^{-1}$, respectively. Mineralogically, the stream sediment samples comprise quartz, muscovite, ilmenite, cassiterite, and goethite. According to the Geoaccumulation index, they are classified as uncontaminated to extremely contaminated in As, Cd and W and uncontaminated to heavily and extremely contaminated in Cu. The Potential Ecological Risk Index (PERI) is very high for As and Cd and high for Cu. Remediation measures, including the recovery of critical raw materials, especially for Cu and W, which are considered critical by the EC (2023), must be evaluated.

**Keywords**: Tailings; Geochemistry; Stream sediments; Ecological Risk

**References**

EC – European Commission: Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, Grohol, M. and Veeh, C.,, 2023. Study on the critical raw materials for the EU 2023 – Final report, Publications Office of the European Union, 2023, https://data.europa.eu/doi/10.2873/725585)

# Cycling of elemental mercury vapor controls the sink and isotopic fractionation of atmospheric mercury in forest ecosystems

Xinbin Feng[1], Wei Yuan[1], Xun Wang[1]

[1]Institute of Geochemistry, Chinese Academy of Sciences, Beijing, China

## Abstrat (oral)

Significant knowledge gaps exist regarding the fate of mercury (Hg) and its isotopic fractionation in forests, which limits the understanding of the global Hg mass budget. For the first time, this study conducted a whole-ecosystem Hg isotope study to depict the Hg biogeochemical processes in a subtropical evergreen forest. Results show that atmospheric Hgo is the primary source of Hg in foliage, woody biomass, throughfall water, runoff water and the food chains of birds. The studied subtropical evergreen forest is an atmospheric $Hg^0$ sink of 57.6±43.9 μg $m^{-2}$ $year^{-1}$ and an atmospheric $Hg^{2+}$ sink of 11.5±6.2 μg $m^{-2}$ $year^{-1}$. The Hg mass-dependent fractionation $Hg^0$ driven by the biogeochemical processes leads to a -0.69±0.58‰ in $\delta^{202}Hg$ of atmospheric $Hg^0$ but an insignificant shift for Δ199Hg. This study provides a protocol for quantifying the atmospheric $Hg^0$ and $Hg^{2+}$ sink over the whole forest ecosystem and the impact of vegetation on $Hg^0$ isotopic shift; and demonstrates the use of stable Hg isotopes in tracing atmospheric Hg cycle in terrestrial ecosystems.

**Keywords**: Mercury; Forest; Stable isotopes

# Study on the changes of arsenic and its species in wild edible fungi after different treatments

Yang Liu[1], Liping Liu[1], Zhangyi Yan[1]

[1]Beijing Center for Disease Prevention and Control

**Abstract (poster)**

Research objective: Edible fungi are a food with high nutritional and medicinal value. In recent years, the consumption of edible fungi worldwide has also increased sharply. While valuing its edible value, it is also necessary to consider its tendency to accumulate toxic chemical elements, such as Arsenic(As) and Mercury (Hg). Among them, As has strong enrichment and biotransformation abilities. Different species of arsenic have different toxicity, and inorganic arsenic(iAs) is much more toxic than organic arsenic. In contrast, arsenic betaine and arsenic choline are considered to be non-toxic. The content and species of arsenic vary among different types of edible fungi. Generally speaking, edible fungi are mostly consumed after cooking and processing, which not only enhances the flavor of the fungi, but also changes the chemical speciation and content of arsenic in food, thereby affecting the bioavailability of arsenic. This study simulated people's daily cooking habits. It explored the changes in arsenic and its species in two wild edible fungi (Pleurotus citrinopileatusone and Agaricus blazei Murill) treated with different cooking methods.

Research method: The determination of total arsenic was carried out using ICP-MS method, and the determination of arsenic species was carried out using HPLC-ICP-MS method. A Dionex IonPac AS7 anion exchange chromatographic column (4×250 mm) and its guard column Dionex IonPac AG7 (4 × 50 mm), and ammonium carbonate was used as the mobile phase for gradient elution.

Research results: The As content of the edible fungi decreased to some extent after soaking, boiling,stir-frying. Both total As and its speciation in cooked edible fungi were lower than those in raw edible fungi (raw > soaking plus stirfrying > soaking plus boiling). We found that the content of As in Pleurotus citrinipileatus and Agaricus blazei Murill reduced by soaking plus stir-frying by 55.4% and 72.9%, respectively. The As content in Pleurotus citrinipileatus and Agaricus blazei Murill decreased by 79.4% and 93.4%, respectively, after soaking plus boiling. The content of As speciation in dried wild edible fungi reduced significantly after different treatments. Among them, iAs decreased by 31.9%~88.3%, and organic As decreased by 33.3%~95.3%.

Research conclusion: Dry edible fungi must be soaked before consumption to simulate people's daily eating habits. This step can remove most of the arsenic, and then cooking methods such as stir-frying and boiling are used for further treatment. The soaking plus boiling method reduces the arsenic and species content in edible fungi the most. This study examines the effect of cooking methods on arsenic levels in edible fungi, providing a more scientific basis for evaluating the health risks associated with consuming these fungi.

**Keywords**: Edible fungi; Arsenic content and its species

# Element analysis and content difference of different kinds of roses

Zhangyi Yan[1], Liping Liu[2], Yang Liu[2]

[1]Capital Medical University. Fengtai District, China, 100054
[2]Beijing Center for Disease Prevention and Control

**Abstract (poster)**

Purposes: As one of the traditional famous flowers in China, the rose is a valuable medicinal material and is widely used in the production of food, healthcare products, and beauty products. The efficacy of roses is closely related to the elements they contain, but at present, there are few studies on the elements in roses, and the varieties are single. The purpose of this study is to explore the content characteristics of inorganic elements in roses and to understand the relationship between the differences in element content and nutritional value in roses.

Methods: In this study, the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method was established to determine the contents of 31 elements in fresh samples of four kinds of roses: Mohong rose, Dianhong rose, Pingyin rose, and Damascus rose. The distribution characteristics of elements in different types of roses were analyzed.

Results: It was found that the contents of inorganic elements in rose samples were quite different, and the elements in roses were K, Ca, Mg, Na, Fe, Al, Mn and Zn. The contents of major elements K, Ca, Mg and Na in rose samples are generally high. Potassium is the highest element in roses; the average content of K in roses is more than 2.5 g $kg^{-1}$. The average contents of Ca and Mg are more than 0.4 g $kg^{-1}$ and 0.3 g $kg^{-1}$. Among them, the K content of Mohong rose and Dianhong rose is significantly higher, with an average content of 4 g $kg^{-1}$, and the Ca content of Pingyin rose is higher, with an average content of 0.75 g $kg^{-1}$. Damascus rose contains a lot of Na, with an average content of 0.32 g $kg^{-1}$. Roses are also rich in trace elements such as Fe, Mn, Zn and Cu. The average contents of Fe, Mn and Zn in all varieties of roses are over 3.0 mg $kg^{-1}$, and the Fe content in the Dianhong rose is high, with an average content of 14 mg $kg^{-1}$. The Mn content of Mohong rose is high, with an average content of 8 mg $kg^{-1}$. The content of Cu in all varieties of roses is generally low, with an average content of less than 1 mg $kg^{-1}$. Harmful elements such As, Pb, Cd, Hg and As in all varieties of roses meet the requirements of the National Standard for Food Safety-Limits of Pollutants in Food (GB2762-2022), and the content of Cu meets the requirements of the 2020 edition of China Pharmacopoeia.

Conclusion: The ICP-MS method is simple, accurate, reliable, and suitable for detecting multi-elements in roses. It is found that the element content of different kinds of roses is different; the K content of Mohong roses and Dianhong roses is higher. The content of Fe in Dianhong rose is high; Ca in pingyin rose is high; Na in Damascus rose is high. Rose is rich in beneficial elements, which have potential value in antioxidation, regulating blood oxygen balance and preventing osteoporosis. The content of harmful elements is low, and a homologous substance of medicine and food is worthy of further development and utilization.

**Keywords**: Rose; Elemental analysis; Content difference

# Metal(loid)s in agricultural topsoils of Tarrafal and Assomada (Santiago island, Cape Verde): Assessing enrichment/ contamination and potential ecological risks

Filipa Moreno[1], Marina Cabral Pinto[2], Maria Orquídia Neves[3], Maria Manuela Inácio[1]

[1]Instituto Dom Luiz (IDL), Faculdade de Ciências, Universidade de Lisboa, 1749- 016 Lisboa, Portugal
[2]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal
[3]Centro de Recursos Naturais e Ambiente (CERENA), Departamento de Engenharia de Recursos Minerais e Energéticos (DER), Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal

## Abstract (poster)

Assessing metal(loid) enrichment/contamination in agricultural soils is essential for soil quality, crop safety, sustainability, and farming practices, particularly in countries like Cape Verde, where limited awareness of the toxic effects on human and plant health worsens the problem. In Santiago island, agriculture plays a key role in local livelihoods. However, metal(loid) accumulation in soils, whether geogenic, climatic or human-induced, can threaten food security and people's well-being. Therefore, understanding contamination and ecological risks in its agroecosystems is imperative to preserve soil's social value and overall health. This study focuses on As, Cd, Cr, Cu, Hg, Ni, Pb, Zn enrichment/ contamination and the associated ecological risks in topsoils from two Santiago areas: Assomada, an inland town, and Tarrafal, a coastal city with some agricultural associations (e.g., Colonato). The targeted metal(loid)s, often found in high concentrations in manure, compost, and untreated sewage sludge – commonly applied to farmlands – can accumulate to toxic levels, damaging crops and productivity over time. In November 2019, nine topsoils (0–15 cm) were collected from Tarrafal (T) and six from Assomada (A). The samples (<2 mm) were analysed by Inductively Coupled Plasma Mass Spectrometry at ActLabs, after acid extraction ($HNO_3$+HCl). Two indices were used to assess soil quality and ecological risk: the Modified Pollution Index (MPI) and the Modified Ecological Risk Index (MRI), both based on Enrichment Factors (EFs), with Sc as the normalizing element. Santiago background values for As, Cr, Cu, Ni, Pb, Zn, and Sc, alongside medians for Cd and Hg (for which background data are unavailable) were sourced from previous studies on the island. The EFs ranged as follows: EFAs: 0.1–6.8 (2.3±1.3); EFCd: 0.4-3.3 (1.6±0.7); EFCr; 0.1-1.1 (0.5±0.2); EFCu = EFNi, 0.1-1.3 (med±MAD: 0.5±0.2); EFHg, 0.2-11.1 (0.8±1.6); EFPb, 0.6-36.7 (2.8±6.5) and EFZn, 0.8-5.5 (2.0±0.8). Each EFCu, EFPb, and EFZn presented one first-order outlier, while EFHg had two second-order outliers. All soil samples containing outliers are associated with crops, namely lemon balm (Melissa officinalis L.), cassava (Manihot esculenta Crantz.), and sweet potato (Ipomoea batatas (L.) Lam.), as well as tea and base foodstuff plants, which can raise some concern. Significant median EF differences were found between the two areas for Pb (EFPb(T)= 11.4 and EFPb(A)= 1.6), As (EFAs(T)= 3.3 and EFAs(A)= 0.7), and Hg (EFHg(T)= 0.2; EFHg(A)= 1.8) (two-tailed test; $p< 0.05$). The MPI indicated varying contamination levels, with Tarrafal topsoils registering higher contamination, from slightly ($1 \leq MPI < 2$) to heavily ($MPI \geq 10$). In contrast, Assomada's samples were mostly slightly contaminated, with two showing severe contamination ($5 \leq MPI < 10$). The ecological risk, expressed by the MRI, was linearly correlated with the MPI ($R2= 0.73$; $p< 0.05$), ranging from low ($MRI < 150$) to very high ($MRI \geq 600$) at a site in Tarrafal. The Pb and Cd contributed most to ecological risk in Tarrafal, and Hg in Assomada. Continuous monitoring of soils and agricultural products is advisable to prevent toxic levels and protect human populations and livestock. Additionally, ecotoxicological testing is necessary for a more comprehensive assessment of soil quality.

**Keywords**: Metal(loid)s; Enrichment/Contamination; Soil quality; Ecological risk assessment; Santiago island.

# Hydrochemical variability between 2012 and 2022 of relevant chemical and physicochemical parameters of fractured aquifer in Costa Azul (Uruguay)

Mariano Cáceres[1], Karina Pamoukaghlian[2], Elena Alvareda[3]

[1]Área Toxicología, Departamento Estrella Campos, Facultad de Química, Udelar. Av. Gral. Flores 2124, (11800) Montevideo, Uruguay
[2]Instituto de Ciencias Geológicas, Facultad de Ciencias, Udelar, Iguá 4225, (11400) Montevideo, Uruguay
[3]Departamento del Agua, Centro Universitario Regional Litoral Norte, Udelar, Gral. Rivera 1350, (50000) Salto, Uruguay

## Abstract (oral)

Costa Azul is a small coastal town in southern Uruguay, covering an area of 1.62 km$^2$. It is situated along the Río de la Plata estuary, approximately 54 km from Montevideo, the capital of Uruguay. According to the 2023 Census, the town has a population of 1,776 inhabitants, which can accommodate up to ten times its permanent population during the summer season. The drinking water supply is provided through a network managed by Obras Sanitarias del Estado (O.S.E.), which utilizes multiple water sources.

The objective of this study was to analyze the hydrochemical variations in the groundwater of a fractured aquifer in the aforementioned locality between 2012 and 2022. The aquifer is hosted in a Paleoproterozoic crystalline basement. The study aimed to establish a baseline and identify potential issues by examining specific chemical and physicochemical parameters. The chemical parameters considered in the survey included pH, electrical conductivity (EC), total hardness (TH), total alkalinity (TA), nitrates ($NO_3^-$), nitrites ($NO_2^-$), ammonia ($NH_4^+$), chlorides ($Cl^-$), sulfates ($SO_4^{2-}$), fluorides ($F^-$), iron (Fe), manganese (Mn), zinc (Zn), sodium (Na), lead (Pb), arsenic (As), cadmium (Cd), chromium (Cr), selenium (Se), and copper (Cu). O.S.E. provided data from a total of 7 wells that had undergone resampling. The sampling intervals were irregular, and the resampling events varied between 2 and 25 per well.

Variations were observed in several parameters, including alkalinity (187–604 mgL$^{-1}$), conductivity (574 - 2076 µS cm$^{-1}$), chloride (44 - 273 mg L$^{-1}$), sodium (58 - 346 mg L$^{-1}$), arsenic (0.002 - 0.017 mg L$^{-1}$), and manganese (0.02 - 0.21 mg L$^{-1}$) in some wells. Arsenic exhibited slight variations, with a mean concentration of 0.010 mg L$^{-1}$, which could be related to aquifer exploitation. Sodium appeared to have a geogenic origin, with the highest concentrations found in the non-urbanized area farther from the coast.

This study offers valuable insights into the aquifer's hydrochemical dynamics and highlights potential concerns regarding groundwater quality in Costa Azul.

**Keywords**: Hydrochemistry; Arsenic; Sodium; Variability; Groundwater

# The biogeochemistry of aluminum in a hidden hydrothermal zone in Mexico

Zayre I. González Acevedo[1], Marco A. García Zarate[2], Daniel Vela-Gódinez[3], Rolando Peralta-De Hoyos[1]

[1]Centro de Investigación Científica y de Educación Superior de Ensenada, Department of Geology, Baja California, México
[2]Centro de Investigación Científica y de Educación Superior de Ensenada, Department of Optics, Baja California, México
[3]Postgraduate Program on Earth Sciences, orientation on Environmental Geosciences

**Abstract (oral)**

Aluminum (Al) is the third most abundant element in the Earth's crust. Although it has no known essential role in biological systems, the average daily intake for humans, primarily through food, is estimated at 10 mg. Higher intakes have been associated with neurodegenerative diseases such as Alzheimer's, Parkinson's, and multiple sclerosis. Hydrothermal zones are significant sources of major and trace elements to various environmental matrices, including air, water, soil, vegetation, and fauna. This study investigates the biogeochemistry of aluminium (Al) in the Acoculco Caldera, situated in Puebla, Mexico, south of the Trans-Mexican Volcanic Belt. Samples of water, soil, plants and fungi were collected within different seasons and analyzed in both hydrothermal and non-hydrothermal areas. Additionally, a sequential extraction was performed on the first soil horizon to assess the presence of Al at different soil phases. Results indicate that hydrothermal waters in the study area exhibit acidic pH values (2-4) and temperatures reaching 24 °C. Al concentrations in these waters exceeded the World Health Organization's recommended limit (0.2 mg $L^{-1}$) by a factor of 50 to 100. In hydrothermal zones, Al accumulation in plants correlated with elements of geogenic origin, such as Si, Sr, Ti, Y, Ga, and Ce. Notably, the fungus Amanita muscaria contained lower Al concentrations in hydrothermal areas than non-hydrothermal sites, whereas plants showed the opposite trend. Soils in hydrothermal zones were also acidic (pH 2-4), with clay and sandy loam textures. Elemental composition showed an abundance of Si > Al > Fe. Sequential extraction revealed that 67% of Al was present in the exchangeable fraction, followed by organic matter (20%), Fe-Mn hydroxides (5%), and the residual fraction (3%). However, the enrichment factor and the geoaccumulation index indicated minimal Al enrichment in the region. These findings suggest that hydrothermal water is the primary source of Al in the environment, with transfer mechanisms occurring primarily

through soil mineral weathering in the exchangeable fraction. The uptake of Al by plants in hydrothermal zones further supports this hypothesis. Since small hydrothermal lagoons in the area are traditionally used for medicinal baths and even consumed as drinking water, believed to alleviate pain and treat skin diseases in humans and domestic animals, preventive measures should be considered to mitigate potential health risks associated with Al exposure.

**Keywords**: Water; Soil; Plants; Fungi; Exposure

# Impact of vitiviniculture practices on soil health: insights from Quinta do Casal da Granja, Portugal

Catarina Ganilho[1], Rui Soares[2], Anabela Cachada[1,3], Tatiana Andreani[1,4,5], Ruth Pereira[1]

[1]GreenUPorto - Sustainable Agrifood Production Research Centre & INOV4AGRO, Department of Biology, Faculty of Sciences, University of Porto, Rua Campo Alegre s/n, 4169-007, Porto, Portugal
[2]Wine Company Real Companhia Velha, Rua de Azevedo Magalhães, 314, 4430-022 Vila Nova de Gaia, Porto, Portugal
[3]Department of Geosciences, Environment and Spatial Plannings, Faculty of Sciences, University of Porto, Rua Campo Alegre s/n, 4169-007, Porto, Portugal
[4]Chemistry Research Centre (CIQUP) & Institute of Molecular Sciences (IMS), Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, Porto, Portugal
[5]Center for Research and Technology for Agro-Environmental and Biological Sciences (CITAB-UTAD) & Inov4Agro, Quinta de Prados, 5001-801 Vila Real, Portugal

## Abstract (poster)

Viticulture and wine production hold significant cultural and economic importance in Europe. The quality of wine is influenced by the complex interaction between physical environments (edaphoclimatic factors) and biota (microbiota and edaphic fauna), contributing to defining the terroir. Therefore, it is crucial to monitor the impacts of viticulture practices on soil health, as biotic factors influence vine development, grape production, and the provision of various ecosystem services. This study aims to validate the sensitivity of biological indicators in response to integrated production practices on Quinta do Casal da Granja (Real Companhia Velha, Alijó, Portugal). A vineyard sampling plan was co-created with wine growers considering the phytosanitary protocols applied to two different grape varieties: Moscatel Galego (more sensitive to pressure from pathogens) and Arinto (less sensitive - a greater sensitivity of the variety refers to the two main diseases that affect the vine crop: downy mildew and powdery mildew) and it was carried out in the between-row space and under-the-row strip of the vineyard rows for comparison purposes. The study began with soil sampling for biological indicators in the selected plots (three vineyard plots per each grape variety) and for physical and chemical characterisation. The effects of the application of plant protection products (PPPs) are being assessed with a soil microbial community analysis using soil enzymes (dehydrogenase, urease, CM-cellulase, arylsulfatase, acid phosphatase activities) and nitrogen mineralisation and nitrification potential. The functional profile of soil microbiota (EcoPlate™ biolog) will also be evaluated. The results show that the soil physical and chemical parameters differ between plots, even within the same farm, particularly regarding soil organic matter content (values between 4.84% to 11.15%) and water holding capacity (values between 48.3% to 89.0%). The soil enzymes revealed a relationship with PPP utilisation, dehydrogenase, CM-cellulase, arylsulfatase and nitrogen mineralisation showed higher activity in the between-row space, where PPPs input is low, while urease and nitrification potential were highest in the under-the-row strip, which is subject to more intense pressure from the PPP. In most cases, it was found that biological activity tended to be greater in between-row space and in the Arinto grape variety where there is no direct influence of PPPs. This study highlights the challenges associated with conducting field experiments to assess agricultural practices, underscoring the importance of a detailed understanding of the interactions between management practices and soil characteristics.

**Keywords**: Biological indicators; Microbial community; Agricultural practices; Plant protection products

# Trace element bioaccumulation in benthic invertebrates from Ria de Aveiro: exploring species-specific variations and ecological implications

Valéria Giménez[1], Beatriz Neves[2], Carla Patinha[3], Pedro Pato[3], Eduardo Ferreira da Silva[3], Etelvina Figueira[1], Adília Pires[1]

[1]Centre for Environmental and Marine Studies (CESAM), Department of Biology, University of Aveiro, 3810-193 Aveiro, Portugal
[2]Department of Biology, University of Aveiro, 3810-193 Aveiro, Portugal
[3]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal

## Abstract (oral)

Coastal ecosystems, such as estuaries, often act as direct sinks for toxic elements due to the discharge of eJluents from anthropogenic activities. These areas frequently face contamination by trace elements (TEs), which pose significant ecological risks and degrade natural environmental conditions. Ria de Aveiro, an estuarine system in northwestern Portugal, is a permanent habitat for diverse species of fauna and flora. Among marine invertebrates, polychaetes and bivalves play critical roles in enhancing species biomass and richness, occupying lower levels of the food web.

This study assessed TEs bioaccumulation in two benthic species from eight areas along Ria de Aveiro lagoon: the polychaete Hediste diversicolor, a bioturbator and omnivorous predator and the bivalve Scrobicularia plana, a deposit feeder that lives buried in sediments. TEs were quantified using inductively coupled plasma-mass spectrometry (ICPMS), and 36 elements were quantified. Spatial variation in TEs concentrations was observed, with bioaccumulation being site and species-specific. Manganese (Mn) (48.92 mg $kg^{-1}$)> Zinc (Zn) (46.05 mg $kg^{-1}$)> Lithium (Li) (16.61 mg $kg^{-1}$)> Cerium (Ce) (13.31 mg $kg^{-1}$)> Rubidium (Rb) (13.22 mg $kg^{-1}$), were the elements with higher concentrations in sediments.

Additionally, site G (Murtosa Channel, located near Laranjo Bay, a historically contaminated site) had the highest total TE concentration. Site B (S. Jacinto Channel, an area less affected by anthropogenic pressures) showed the lowest total TEs concentration. Regarding bioaccumulation, the results showed that S. plana generally bioaccumulated higher TEs concentrations than H. diversicolor. For S. plana, the most bioaccumulated elements were zinc (Zn) (658.69 µg $kg^{-1}$)> Strontium (Sr) (153.69 µg $kg^{-1}$)> Mn (61.63 µg $kg^{-1}$)> Copper (Cu) (38.27 µg $kg^{-1}$)> Arsenic (As) (36.84 µg $kg^{-1}$), while H. diversicolor bioaccumulated higher levels of Zn (276.66 µg $kg^{-1}$)> Mn (85.83 µg $kg^{-1}$)> Sr (77.07 µg $kg^{-1}$) > Vanadium (V) (49.63 µg $kg^{-1}$)> Cu (32.84 µg $kg^{-1}$). These findings demonstrate that despite cohabiting in the same environment, organisms' feeding behavior and ecological roles influence TEs bioaccumulation between species.

**Keywords**: Bioaccumulation; Polychaetes; Bivalves; Sediment contamination

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# Geogenic and anthropogenic sources of arsenic contamination in Nigeria: a systematic review of contribution from mining

K'tso Nghargbu[1]

[1]Nasarawa State University, Keffi, 911019, Nigéria

## Abstract (poster)

Arsenic contamination and poisoning are well-established geomedical phenomena worldwide. Some of its sources are geogenic, while others are anthropogenic. This paper aims to address concerns arising from mining-related sources of this toxic substance, as Nigeria is endowed with diverse minerals across its six geopolitical zones, which are currently mined at various stages of technological advancement. Their mining/exploitation comes with attendant environmental consequences, compelling researchers and policymakers to take a closer look at the multiple contaminants to provide safety and health checks at mineral exploitation sites, targeting the minimisation of mining-related occupational health diseases on the rise in Nigeria. A review of literature on Arsenic Pollution in Nigeria informed the basis for this work.

**Keywords**: Geomedical; Arsenic; Contamination; Occupational Health Diseases; Nigeria

# The various effects of biochar on Cd uptake in rice: evidences from field experiments

De Chen[1], Xuezhu Ye[1]

[1]Institute of Agro-product Safety and Nutrition, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, Zhejiang, China

## Abstract (oral)

Soil contamination by cadmium (Cd) and its accumulation in rice pose significant global environmental and food safety challenges. Biochar has emerged as an effective soil amendment for mitigating Cd bioavailability in paddy soils. However, biochar affected Cd bioavailability in the soil-rice system, especially in field conditions. This study summarizes the overall impact of field application of biochar on soil Cd availability and rice uptake in recent years, as well as the effects of interannual climate variations, rice varieties, and soil conditions. (1) There were significant differences among different biochars on soil Cd bioavailability, depending on the production conditions and raw materials of biochar; (2) There were significant variations in Cd accumulation among different rice cultivars in response to biochar treatment; (3) Interannual climatic variability, particularly temperature and precipitation fluctuations, strongly influenced grain Cd levels, indicating that neither low-Cd cultivars nor biochar application alone could consistently ensure compliance with national safety standards. Combining biochar and low-Cd-accumulating cultivars offers a more reliable strategy for sustainable rice production in Cd-contaminated soils.

**Keywords**: Biochar; Heavy metal uptake; Rice cultivar; Safe utilization of contaminated farmland

# Environmental assessment of a wetland system for the treatment of acid mine drainage (AMD) at Lousal Mine (Portugal)

Miguel Rodrigues[1], Eduardo Ferreira da Silva[1,3], Salomé F.P. Almeida[2,3], Nuno Durães[1,3]

[1]Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal
[2]Department of Biology, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal
[3]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal

## Abstract (poster)

The Iberian Pyrite Belt (IPB) has been a centre of polymetallic sulphide ore exploitation since pre-Roman times. Decades of intensive sulphide mining in the IPB have led to significant environmental legacies, notably the generation of acid mine drainage (AMD). To address these impacts, the Empresa de Desenvolvimento Mineiro (EDM), under an environmental rehabilitation initiative, implemented an AMD treatment system at the Lousal site, integrating both passive and active remediation approaches, which includes 17 treatment wetland units interconnected by aeration channels with lime substratum. The main objectives of this system are to reduce metal(loid) mobility through precipitation and phytoremediation, and to neutralise acidity, thereby limiting the dispersion of contaminants into the natural aquatic systems.

In this study, a multidisciplinary assessment was undertaken to evaluate the treatment system's effectiveness, including analyses of water, sediments, and diatom communities. Samples were collected along the treatment network, in the Corona stream (close to the discharge of the treatment system), and from two nearby open pit acidic lagoons.

Preliminary results indicate high concentrations (average values) of several metal(loid)s in the open pit acidic lagoons (Fe>Mn>Zn>Cu>Co>As>Ni>Pb>Cd), followed by the treatment wetland system, (Mn>Fe>Zn>Cu>Co>As>Ni>Cd>Pb) and Corona stream (Mn>Zn>Fe>Cu>Co>Ni>Pb>Cd>As), where metal(loid) concentrations are not significantly different. Although the concentrations of metal(loid)s remain high in the effluent obtained at the end of the treatment system, there is a significant reduction in the concentrations of most of the metal(loid)s analysed, namely for Fe, Cu, As, Cd, Ni and Co in relation to the initial concentrations of the AMD. Nevertheless, a continuous decrease of the amounts of metal(loid)s along the treatment system is not verified, with a great increase in some sections, which can be explained by lateral runoff inputs. Biological monitoring of diatom assemblages revealed low diversity, dominated by acid-tolerant genera such as Nitzschia, Pinnularia and Eunotia. Notably, the absence of major teratological forms suggests these communities are adapted to such acid and highly metallic conditions. Given their sensitivity to environmental change, diatoms are valuable bioindicators for tracking the performance of remediation strategies.

Overall, the results underscore the effectiveness of the Lousal treatment system in mitigating AMD impacts. They also emphasise the importance of regular maintenance to prevent the system from being compromised by external variables/agents. Therefore, ongoing monitoring remains essential to ensure the long-term success of remediation efforts and to enable adaptive management strategies for sustainable ecosystem restoration.

**Keywords**: IPB; AMD; Potentially Toxic Elements; Diatoms; Environmental Remediation System

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# Developing nickel phytomining in ultramafic soils - biochar and citric acid application

Ana R. A. Alves[1], Luis A. B. Novo[2], Eduardo Ferreira da Silva[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal.
[2]Scotland's Rural College, Edinburgh, UK.

## Abstract (oral)

Ultramafic soils, derived from ultramafic rocks (cover about 1% of the Earth's surface), present a peculiar geochemistry, namely, high concentrations of Mg, Fe, trace elements Ni, Cr and Co and depletion in plant essential nutrients. These environments are harsh for traditional agriculture but support specialized plant communities. Hyperaccumulation is a remarkable example of flora adaptation to metalliferous soils in which plants accumulate great amounts of metals in their shoots. Nickel hyperaccumulators (accumulate > 1000 mg $kg^{-1}$ of Ni in shoots) are notable in phytomining studies given their prevalence in ultramafic regions and the demand for Ni.

Phytomining uses plants to extract valuable metals from mineralised or polluted soils. This process involves growing a hyperaccumulator species in a Ni-rich substrate, harvesting when peak biomass and Ni accumulation are reached, and processing for Ni recovery. Agronomic practices are key for improving Ni harvestable amounts (governed by biomass and Ni concentration) and thus phytomining viability. Within a circular economy framework, phytomining offers a sustainable alternative for metal extraction and re-valorisation of low-productivity landscapes. The main goal of this study was to assess the effects of biochar and citric acid in Ni phytomining with the species Odontarrhena serpyllifolia.

Seeds from the native hyperaccumulator and soil were collected from the Bragança ultramafic massif (NE Portugal). Olive pomace (agricultural residue) was also sourced locally for biochar production through pyrolysis, prompting a circular economy. Plants were grown under controlled conditions in soil amended with two biochars produced at 450 (B450) and 550 °C (B550) (applied at 1.5 % w/w), citric acid (10 and 20 mmol $kg^{-1}$, applied 2 weeks before harvest), and their combinations.

Biochar incorporation increased soil pH, conductivity, organic matter content, water-holding capacity, and nutrient levels (N, P, K), as well as Ca/Mg ratios. Nickel accumulation was greater (5489 and 6060 mg $kg^{-1}$ for B450 and B550, respectively) in relation to control (4429 mg $kg^{-1}$). Likewise, the Ni harvestable amount was higher (10.98 and 12.12 mg for B450 and B550, respectively) than the control (7.97 mg $kg^{-1}$). Citric acid was detrimental to plant health, leading to decline and eventual death. Shoot concentrations of Mg, Fe, Mn, Cr, Co, Cu and Na were greater with citric acid application and with increasing citric acid concentration; however, Ni levels remained unchanged. Our findings suggest that biochar enhanced soil properties and increased phytomining yields, indicating its potential as a promising soil amendment. Furthermore, biochar may address the management issue of residue (olive pomace) and contribute to climate neutrality (C-sink).

**Keywords**: Agromining; Phytoextraction; *Alyssum pintodasilvae*; *Alyssum serpyllifolium subsp. lusitanicum*; Organic amendments

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# Characterisation of industrial effluents in the two-wheel industry: a case study of Ciclo Fapril company

Tiago Teixeira[1,3], Mariana Santos Gama[1,2], Flávio Castro Silva[2], Eduardo Ferreira da Silva[1], Maria Helena Nadais[2], Ana Pupo[4], Carla Patinha[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal.
[2]CESAM & Departamento de Ambiente e Ordenamento da Universidade de Aveiro, Campus de Santiago, 3810-193, Aveiro, Portugal.
[3]BIKiNNOV - Bike Value Innovation Center – Association, Rua da Indústria, 369, Covão| 3750-792 Águeda, Portugal.
[4]Ciclo Fapril - Indústrias Metalúrgicas, S.A., Rua Vale do Grou 1378, 3754-908 Águeda, Portugal

## Abstract (poster)

The increasing demand for economically viable, sustainable solutions with lower environmental impact has driven various industrial sectors to rethink their processes, with particular emphasis on reducing the consumption of natural resources and enhancing waste valorisation. The two-wheeler industry plays a significant role within the metallurgical and metalworking sectors in Portugal and is particularly affected by these demands. In this context, the integration of geochemical approaches, such as the chemical characterization of waste and the monitoring of the mobility of certain metals, can be relevant for improving the environmental management of effluents, contributing to the development of more effective treatment solutions. This type of analysis is essential for developing sustainable strategies that reduce environmental impacts, ensure compliance with legislation, and promote circular economy practices within the sector.

The detailed characterisation of effluents is a fundamental step towards optimising and developing more sustainable and environmentally friendly treatment processes. In this context, the present study focused on the characterisation of effluents resulting from the washing and degreasing of metal parts at the company Ciclo Fapril – Indústrias Metalúrgicas, S.A., as well as their mixture in the pre-treatment phase at the industrial wastewater treatment plant. The analysis of parameters such as: pH (1.74 – 11.24); electrical conductivity (1096 – 63200 µS $cm^{-1}$); total and volatile suspended solids (80 – 3940 mg $L^{-1}$ and 0 – 1293 mg $L^{-1}$, respectively); chemical oxygen demand (170 – 67675 mg $L^{-1}$); biochemical oxygen demand after five days (20 – 9400 mg $L^{-1}$); and concentrations of certain metals, namely Al (5 – 180 mg $L^{-1}$); Fe (40 – 516 mg $L^{-1}$); Zn (5 – 466 mg $L^{-1}$); Cr (0.5 – 53 mg $L^{-1}$), enabled the characterisation of effluent variations throughout the operational variations within the industrial process, the identification of seasonal patterns, and the identification of key pollutants. The results revealed a high organic load and presence of metals in specific process stages, particularly during the degreasing phase of metallic components, highlighting the need for adjustments to the existing treatment scheme and the potential for implementing valorisation processes that contribute to reducing environmental impact, in line with the principles of the Circular Economy.

**Keywords**: Industrial wastewaters; Effluent characterisation; Bicycle industry; Sustainability industry practices

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# Hydrochemistry and spatial distribution of geogenic contaminants: arsenic, boron, and lithium as key determinants of groundwater quality in the Bolivian Altiplano.

Lizangela Huallpara[1], Mauricio Ormachea[2], Oswaldo Ramos[2], Prosun Bhattacharya[1]

[1]KTH-Royal Institute of Technology, International Groundwater Arsenic Research Group, Department of Sustainable Development, Environmental Science and Engineering, Teknikringen 76, SE-100 44, Sweden.
[2]IIQ-Instituto de Investigaciones Químicas, Facultad de Ciencias Puras y Naturales, Universidad Mayor de San Andrés, 303, Bolivia.

## Abstract (oral)

Arsenic (As) contamination in drinking water is a global problem, and reports from several regions provide valuable data on this toxic element in groundwater quality assessments. However, studies related to the presence of As with co-occurring geogenic contaminants (GCs) like boron (B) and lithium (Li) in areas with unusual geological characteristics, such as the Lauca River Basin (LRB) of the Bolivian Altiplano (BA), have remained scanty. This study investigates the natural occurrence of high As, B, and Li concentrations using an integrated approach that includes GIS-based mapping, geostatistics, hydrochemistry, and the Groundwater Quality Index (GWQi) model.

Several field and laboratory parameters were analyzed from 89 water samples used for drinking and domestic purposes in the LRB. This analysis included major ions and trace elements using IC and ICP-MS. The analytical results revealed that groundwater samples' As, B, and Li concentrations ranged from 2 to 647 µg $L^{-1}$ for As, 77 to 9649 µg $L^{-1}$ for B, and 1 to 3049 µg $L^{-1}$ for Li, respectively. Groundwater pH varied from 6.1 to 9.8, and electrical conductivity (EC) ranged from 15 to 19850 µS $cm^{-1}$, with the highest values found in water sources near the Coipasa salt flat. The predominant water type is Na-Cl-$HCO_3$. Approximately 50% of the water sources have a high GWQi, indicating a high and very high health risk. The evaluation of possible GWQi anomalies caused by unacceptable levels of important ions and trace elements was carried out by comparing the concentrations with the drinking water standards recommended by the World Health Organization. These unusual hydrogeochemical characteristics are consistent with extremely arid volcanic areas with geothermal fluids, high evaporation rates, and evaporative deposits. The continuous monitoring of BA's water resources is essential to safeguard public health in rural communities that depend on untreated groundwater and promote the sustainable use of these water sources.

**Keywords**: Geogenic contaminants; Hydrochemistry; Groundwater quality; Bolivian Altiplano; Health effects.

# Lithium in soil, vegetation and surface water in the states of São Paulo and Mato Grosso do Sul (Brazil)

Cassio Roberto da Silva[1], Orquídia Neves[2]

[1]Geological Survey of Brazil - CPRM, Av. Pasteur, 404, Urca, Rio de Janeiro-RJ, Brazil, CEP: 22290-250
[2]Centro de Recursos Naturais e Ambiente (CERENA), Departamento de Engenharia de Recursos Minerais e Energéticos (DER), Instituto Superior Técnico, Universidade de Lisboa

## Abstract (oral)

Vegetables provide essential mineral elements for both human and animal nutrition. Although lithium (Li) is not considered an essential element, it contributes to human health (e.g. treatment of mental illnesses). Vegetables and certain types of waters are key sources of Li, allowing for its absorption by humans. The suggested provisional Li daily intake for an adult (70 kg) is 1 mg. Nevertheless, Li concentrations in plants, particularly in food crops, remain limited.

A project conducted by Brazil's Geological Services (PGAGEM) identified Li anomalies in sediments/soils in São Paulo(SP) and Mato Grosso do Sul ( MS) states. Soil and surface water used for irrigation were collected from these regions. Additionally, food species such fruits(oranges, tangerines, bananas, grapes, lemons, avocados, guavas, açaí), vegetables/greens (cabbage, snap beans, garlic, chives, okra, cassava) and others (sugar cane, corn and coffee grains, saffron, Aloe Vera, roses, castor beans, grass) were also collected. This study aims to determine Li content in various sample types and assess their possible correlations.

The soil samples (fraction < 177 µm) were digested with aqua régia ($HNO_3$ and HCl), and plant samples with a mixture of $HNO_3$ and $H_2O_2$, according to EMBRAPA methodologies. The extract solutions and the filtered waters were analyzed through an inductively coupled plasma optical emission spectrometer.

In the SP state, soil samples (n=29) presented Li between 8 and 26 mg $kg^{-1}$, while in MS (n=14), levels ranged between 2 and 26 mg $kg^{-1}$, with both regions showing a median of 11 mg $kg^{-1}$, considered an anomalous national value. Nonetheless, they are lower than those found in Araçuai (MG) region (n=46 soil samples), where Li range from 17.2 to 281.4 mg $kg^{-1}$ (median: 72.6), attributed to local Li-bearing granitic rocks. Since 1966, the Companhia Brasileira de Lítio has been actively exploring spodumene pegmatites.

In 79% of the plants sampled from both states (17 fruits, 21 vegetables, 22 grasses and 20 other plant types), Li was below the detection limit (DL 5 µg $kg^{-1}$). Higher concentrations (µg $kg^{-1}$ dry weight) were identified in 9 samples from SP (30.3 in chives, 5.8 to 93 in sugar cane, 37.6 in Aloe Vera, used for medicinal purposes, and 5.7 and 34.3 in grass, for animal feed. In 6 samples from MS, the Li levels were 189.2 in corn, 53.6 in saffron, 5.8 and 121.8 in chives, 5.5 and 5.2 in grass and orange, respectively. However, some species exhibited Li below the DL in various sampling locations. In Araçuai (MG), samples (n=12) of cabbage, beans, chives, and mustard had Li between 0.26 and 6.68 mg kg-1 dry weight, with the highest concentration found in mustard.

In surface waters, the Li concentration was similar in SP: 5 to 12 µg $L^{-1}$ (n=29) and in MS: 5 to 8 µg $L^{-1}$ (n=14). Greater variability was observed in Araçuí (MG) running waters (0.7 to 4.29 mg $L^{-1}$; n=51), but with a median of 0.8 µg $L^{-1}$. No samples exceeded the level of 2.5 mg $L^{-1}$, established by CONAMA 357 for irrigation. Among the plants evaluated, Li does not show a relationship with irrigation water and does not reveal a correlation with its content in the soil.

**Keywords**: Lithium in Brazil, Lithium soil-water-plant system, Lithium and food

# Mineral resources applied to human health: the MINERAL Platform

Cláudia Paiva Silva[1], José Carlos Kullberg[2], Jorge Cristino[3]

[1]Plataforma Mineral & EDM – Empresa de Desenvolvimento Mineiro S.A, Rua Sampaio e Pina, 1 – 8º, 1070-248, Lisboa
[2]Departamento de Ciências da Terra, NOVA FCT, GeoBioTec polo NOVA FCT, Campus de Caparica, 2829-516 Caparica, Sociedade Geológica de Portugal & Plataforma Mineral
[3]Plataforma Mineral & Get2C, Avenida General Humberto Delgado, 49 - 7370-106 Campo Maior

## Abstract (oral)

The presence of mineral resources from ancient times to modern society is undeniable. From agriculture, construction and industrial sectors to technology, as well as most materials we use in our daily lives, they are intrinsically linked to geodiversity, resources, and raw materials, which have been a subject of recent discussion. However, communicating mineral resources presents several challenges, particularly due to the type of language and examples often used, such as academic terminology or complex case studies that fail to engage specific target audiences. Additionally, the negative connotation associated with exploration and prospecting persists, despite the recognition that progress is impossible without materials. To bridge this gap, the MINERAL Platform was created, a group formed by associations, companies, and institutions representing the value chain of the mineral resources sector, aiming for more transparent and more assertive engaging communication with society. Furthermore, its objectives are also to promote the relationship between resources and their applications in daily life, as essential to human well-being in general and health in particular. Covering fields such as Medicine, the pharmaceutical industry, cosmetics and related technology, this approach serves as another way to highlight their significance. Lithium, magnesium, platinum, various types of clays and sands, among others, or even the use of water, such as thermal waters, are clear examples of their applications. Presenting the public with historical facts on the evolution of healthcare practices based on these examples, their current applications, services associated with, as well as everyday products, can offer a more positive perspective, not only on the role of mineral resources but also as a reminder of their importance to our health and expected longer life with quality.

**Keywords**: Mineral resources; Human health; Communication; MINERAL Platform.

# Potential toxic elements in San Antonio stream sediments of Salto Uruguay district.

Sofía da Rocha[1,2], Elena Alvareda[2], Andrés Saracho[2], Eliana Daleve[2], Pablo Gamazo[2], Valery Bühl[3], Rafael Navas[2]

[1]Programa de Posgrado, Facultad de Química, Universidad de la República, Montevideo, Uruguay.
[2]Departamento del Agua, Centro Universitario Regional Litoral Norte, Universidad de la República, Rivera 1350, Salto, Uruguay..
[3]Química Analítica, Facultad de Química, Universidad de la República, Gral. Montevideo, Uruguay

## Abstract (oral)

Potential toxic elements (PTE) are among the toxic substances that enter the environment and accumulate in various living beings, including humans. The impact generated by the high concentrations of these elements in watercourses limits the use of these resources, as the accumulation poses a long-term threat to both the environment and human health. Salto city is located in the so-called horticultural belt, one of the most important areas of Uruguay of horticultural production. Silveira et al. (2020) report the existence of 236 farms located in this area. These production systems are characterized by high-intensity use of soil and water resources, with San Antonio Stream (SAS) and Salto-Arapey Aquifer System (SAAS) the most important water sources for irrigation, livestock and human consumption. The municipal landfill and mechanical workshops are located in SAS basin, where solid waste and untreated wastewater effluent are deposited. Alvareda et al. (2019) has shown the presence of Arsenic (1.0 - 5.0 ug $L^{-1}$), Total Phosphorus (20.0 - 178.5 ug $L^{-1}$), Total Nitrogen (0.2 - 1.8 mg $L^{-1}$), Zinc (15.4 - 396.0 ug $L^{-1}$), Cr (3.1 ug $L^{-1}$ one well) physicochemical and microbiological parameters in SAS. These results evidenced pollution. PTE like Lead (4.5-6.3 mg $kg^{-1}$) and Zinc (16.0 - 73.0 mg $kg^{-1}$) in sediments of SAS near the intensive horticultural crops area were detected by Da Rocha et al. (2024) (unpublished results detected).

For this reason, this work aims to study the sediments of the SAS and identify a possible long-term accumulation of PTE. For this purpose, 10 monitoring sites were selected on the SAS, 30 sediment samples were collected, and PTE, such as Zn and Pb, were analysed. Samples were treated using the EPA 3050B method, and elements were analyzed by a Perkin Elmer 900F Flame Atomic Absorption Spectrometer APHA-3500 with previously optimized and validated methodology. Results showed values of Pb 38.8 - 71.5 mg $kg^{-1}$ and Zn 5.3 - 87.9 mg $kg^{-1}$. For Pb, the results obtained are above the Lowest Effect Level established by the reference normative. For Zn, the results obtained are below the limits established by the reference normative. These results enable the creation of a database for the first time in this area of Uruguay, allowing start to study of geochemical anomalies in sediments with some adverse impact on human and animal health and environmental problems, which is vital because PTEs represent a significant risk due to their toxicity and ability to accumulate in organisms, affecting human and animal health and the environment.

**Keywords**: Stream Sediments; Metals; Human health

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# theme 2

## organic and emergent pollutants

# Driving mechanism and risk assessment of antibiotic pollution in urban water environment based on multi-model coupling: a case study of Suzhou City

Hu Zhao[1], Xianjing Song[1], Jinxu Fan[1]

[1]National Research Center for Geoanalysis, Key Laboratory of Eco-Geochemistry, Ministry of Natural Resource, China

**Abstract (oral)**

As a new type of environmental pollutant, antibiotic pollution has posed a serious threat to the security of the water ecosystem. Exploring the spatial heterogeneity driving mechanism and risk management has become a current research focus. In this study, Suzhou, a typical city in the Yangtze River Delta, was selected as the research object, and a multi-model coupling analysis framework was built by integrating the Geoweighted regression (GWR), GeoDetector and Sandwich interpolation models to systematically analyze the spatial differentiation, multi-source driving mechanism and ecological risk of antibiotics in water. The results show that (1) A total of 13 antibiotics in 3 categories were detected in the study area, and sulfamethoxazole antibiotics (especially sulfamethoxazole SMX) dominated the study area (the detection rate accounted for 18.52%). The spatial distribution of their concentrations showed a radiating decreasing trend from the central urban area to the surrounding counties. Still, a significant high value area was formed in Zhouzhuang Town, the intersection of Kunshan City and Wujiang City in the southeast, and the lower reaches of Changhu River in the north. (2) Through multi-source analysis, the study regions were divided into agricultural non-point source dominant area (northeast), medical point source impact area (central urban area), aquaculture intensive area (southern area) and composite pollution area (central area), revealing that the leading driving factors of each region were highly consistent with the characteristics of pollution sources, and the two factors interaction showed synergistic enhancement effect. The q value of interaction between pharmaceutical enterprises and other driving factors (such as population density and aquaculture) was generally >0.9, indicating a significant spatial leading role. (3) The assessment based on the ecological risk entropy method showed that roxithromycin (ROX) and clarithromycin (CTM) presented a higher risk grade (RQs>1) in the detected sampling points, and the spatial difference of the multi-antibiotic joint risk index (RQsum) was significant (0.04-3.51). The northern region exhibited high-risk aggregation (RQsum > 2.28). The comprehensive analysis method system of “source analysis - driving mechanism - risk assessment” established in this study can be used for urban watershed

**Keywords**: Antibiotic; Water environment; Ecological risk assessment; Spatial distribution

# Determination of per- and polyfluoroalkyl substances in water using direct injection by liquid chromatography- high-sensitivity triple quadrupole tandem mass spectrometry

Yi Huang[1,2], Qi-Feng Li[1,3], Zhu Rao[1,2], Shuai Zhu[1,2]

[1]National Research Center for Geo analysis (NRCGA), Beijing 100037, China
[2]Key Laboratory of Eco-Geochemistry, Ministry of Natural Resources of China, Beijing 100037, China
[3]Beijing Institute of Technology, Beijing 100081, China

## Abstract (oral)

Perfluoroalkyl and polyfluoroalkyl substances (PFAS), as typical persistent organic pollutants, have been widely distributed in global water bodies and soils due to their extensive use in industry and consumer products. Their strong bioaccumulation potential, long-range transportability, and potential carcinogenicity have led the EU, the US, and China to include them in priority control lists. The current mainstream detection method is based on solid-phase extraction coupled with liquid chromatography-tandem mass spectrometry (SPE-LC-MS/MS), which suffers from complex sample preparation, long analysis times (>30 min), and high consumption of organic solvents, limiting large-scale environmental screening. In this study, we developed a rapid detection technique using direct injection-ultra-performance liquid chromatography-high-resolution tandem mass spectrometry (DI-UPLC-HRMS). By optimizing the chromatographic gradient (using an ammonium acetate-water-methanol system) and mass spectrometry parameters, we achieved simultaneous quantitative analysis of 53 PFAS compounds in water samples, including perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and emerging alternatives. Compared with traditional methods, our technique has three major advantages: 1. Sample preparation requires only 0.5 mL of water sample filtered through a 0.22 μm membrane, eliminating the need for solid-phase extraction (SPE) enrichment and derivatization. 2. The analysis time is reduced to 8 minutes per sample, representing a threefold increase in efficiency. 3. The consumption of organic solvents is minimized to 200 μL per sample, a 90% reduction. Using isotopic internal standards, the method detection limits (LODs) were achieved at 0.05-0.3 ng $L^{-1}$ (S/N ≥ 3), which is 5-10 times more sensitive than EPA Method 537.1 (LOD 0.5-2 ng $L^{-1}$), effectively suppressing matrix effects in complex matrices. We applied this method to analyze 117 surface water, groundwater, and landfill leachate samples from 14 cities in China, detecting 23 PFAS compounds with total concentrations ranging from 26.6 to 2832.6 ng $L^{-1}$. Perfluorobutanoic acid (PFBA), PFOA, perfluoroundecanoic acid (PFUdA), and perfluorobutane sulfonate (PFBS) were detected at rates exceeding 80%, making them the predominant pollutants. Our technique overcomes the limitations of traditional methods in terms of efficiency and cost, providing an efficient solution for screening, tracing pollution, and assessing exposure to trace PFAS in environmental and biological samples. It holds significant importance for improving the monitoring system for emerging pollutants, managing environmental risks, and safeguarding public health.

**Keywords**: Per- and polyfluoroalkyl substances; Rapid targeted analysis method; Occurrence and characteristics; Environmental monitoring and risk assessment

# Simultaneous exposure to avermectin enhances the toxicity of R-dinotefuran and reduces the toxicity of S-dinotefuran

Zongqi Hu[1], Caihao Mou[1], Rui Wang[1], Yixiang Wang[1], Shitao Hu[1], Lili Fu1, Quan Zhang[1]

[1]College of Environment, Zhejiang University of Technology, Hangzhou, Zhejiang, 310032, China

## Abstract (poster)

Due to the threats of neonicotinoids to honeybee health, the screening of chiral isomers of neonicotinoids that are less toxic to non-target organisms is a promising protective approach. However, it remained unclear whether these safer isomers could retain their toxic profile when co-exposed with other agrochemicals. This study selected avermectin, a fungicide frequently detected in pollen, for simultaneous exposure with the chiral dinotefuran on Apis mellifera to assess the safety of the isomers under a realistic scenario. The results revealed that the 24-hour $LD_{50}$ for the combination of S-dinotefuran and avermectin exposure was 0.005 μg/bee, compared to 0.0215 μg/bee for R-dinotefuran. Notably, under the combined action of avermectin, the toxicity difference between R-dinotefuran, previously considered relatively safe, and S-dinotefuran was reduced from 19.75-fold to 4.3-fold. Using the combination index method, distinct interactions between avermectin and the enantiomers of dinotefuran were identified. Avermectin exhibited antagonistic effects with S-dinotefuran from $LD_{50}$ to $LD_{90}$, while it shows a synergistic effect with R-dinotefuran over the same dosing range. The molecular docking results showed that avermectin preempted the S-dinotefuran binding site and occupied the ASP110 amino acid residue of the receptor protein. In contrast, avermectin promoted R-dinotefuran binding to the receptor protein. Molecular dynamics simulations also verified the reliability of these conclusions. The current findings suggest that actual environmental scenarios should be considered when evaluating the safety of chiral pesticides.

**Keywords**: Chiral neonicotinoid insecticide; Fungicide; Molecular docking; Co-exposure; Apis mellifera

# Metabolic profiling and ecotoxicological effects of combined sublethal acetamiprid and epoxiconazole exposure on *Apis mellifera* colonies in field conditions

Zongqi Hu[1], Quan Zhang[1]

[1]Key Laboratory of Microbial Technology for Industrial Pollution Control of Zhejiang Province, College of Environment, Zhejiang University of Technology, Hangzhou, Zhejiang 310032, China

**Abstract (oral)**

The use of neonicotinoid pesticides is a primary factor contributing to the decline of pollinators in agricultural ecosystems. Most laboratory studies on bee ecotoxicology currently focus on acute exposure to individual chemicals. However, under natural field conditions, bees are often exposed to a mixture of chemicals over prolonged periods, and the potential synergistic effects of these substances may lead to an underestimation of the toxicity of each compound. In this study, Apis mellifera was placed in a field condition where it was chronically exposed to a neonicotinoid pesticide commonly found in pollen, acetamiprid, and a triazole fungicide, epoxiconazole, for four months. After exposure, we evaluated the reproductive capacity of Apis mellifera and the morphological parameters of newborn bees. The Apis mellifera in the co-exposed group exhibited earlier signs of head and wing atrophy in newborn bees, and the co-exposed group was more susceptible to mite infestations. To assess the impact of combined exposure on Apis mellifera at the gene level, differential metabolites and gene expression in energy metabolism were conducted. The results of the study showed that only the ACE and co-exposure groups exhibited distinct metabolites associated with oxidative stress, which may be caused by excessive reactive oxygen species (ROS) production due to mitochondrial depolarization induced by acetamiprid. Our results suggest that estimates of lethal effects from a single pesticide may underestimate the threat to bees under realistic conditions. Even chronic exposure to pesticides at environmental concentrations can significantly threaten bee colonies, potentially leading to colony collapse.

**Keywords**: Neonicotinoids; Apis mellifera; Metabolites; Chronic exposure

# Predictive machine learning models for neonicotinoid contamination in surface water: agricultural influences and policy implications

Yixiang Wang[1], Quan Zhang[1], Yijun Yao[2], Haoyu Zhang[1], Zongqi Hu[1], Shitao Hu[1]

[1]College of Environment, Zhejiang University of Technology, Hangzhou, Zhejiang, 310032, China.
[2]Key Laboratory of Soil Environment and Pollution Remediation, Institute of Soil Science, Chinese Academy of Sciences, Nanjing, 210008, China

## Abstract (oral)

The high water solubility of neonicotinoids insecticides (NEOs), combined with the 2014 exemption for seed treatments in the United States, has created regulatory gaps and significantly hindered efforts to assess surface water contamination. In this study, we developed a machine learning model based on 4,270 surface water samples, revealing a consistent increase in NEO concentrations. The mean total concentration of six NEO compounds rose from 0.068 μg $L^{-1}$ in 2000 to 0.127 μg $L^{-1}$ in 2022. Contamination has progressively expanded beyond agricultural zones in the Central Plains, indicating broader geographic impacts. Approximately 89.8% of the nationwide concentration increase can be attributed to agricultural sources, particularly seed coatings for corn, soybeans, and wheat. Scenario-based simulations further indicate that restricting the use of NEOs in seed coatings is critical to halting further degradation of surface water quality. Nationally, 21.3% and 94.7% of basins are subject to moderate-to-high acute and chronic risks to aquatic organisms, respectively. Data from Trout Lake in Wisconsin show a significant negative correlation between predicted NEO concentrations and invertebrate abundance, corroborating the ecological risks identified by our model. These findings underscore the urgent need for stronger federal and state-level oversight of seed treatment practices and curtailing non-essential uses to protect freshwater ecosystems.

**Keywords**: Neonicotinoid Insecticides (NEOs); Prohibition Policy; Aquatic Ecosystem; Ecological Risk; Predicted Concentration

# The toxicological effects of the chiral Dinotefuran in earthworm-microorganism-soil microcosms

Shitao Hu[1], Quan Zhang[1]

[1]College of Environment, Zhejiang University of Technology, Hangzhou, Zhejiang, 310032, China.

## Abstract (oral)

Dinotefuran is a widely used third-generation neonicotinoid, which is of increasing concern due to its persistence and potential risk to soil ecosystems. Despite its chiral structure, dinotefuran is typically treated as a single compound in environmental risk assessments, overlooking the differences in selectivity between its enantiomers. In this study, dinotefuran enantiomers were investigated for their enantioselective degradation, bioaccumulation, toxicity, and detoxification mechanisms in an earthworm-microbe-soil microcosm system constructed with natural agricultural soil collected from Huzhou, China. A 28-day continuous exposure design was employed to assess the time-dependent effects of dinotefuran enantiomers on degradation, bioaccumulation, and toxicity. Results demonstrated that S-dinotefuran exhibited higher persistence in soil than R-dinotefuran, especially in earthworm-amended soils, suggesting enhanced enantioselective degradation mediated by earthworm activity. In parallel, S-dinotefuran displayed preferential bioaccumulation in earthworms, with a peak bio-soil accumulation factors (BSAF) value four times greater than that of R-dinotefuran. Toxicity assays further revealed that S-dinotefuran possessed markedly higher toxicity, with acute and behavioral toxicity 13.28-fold and 18.2-fold higher than those of R-dinotefuran, respectively. To elucidate the toxicological mechanism of the observed enantioselective effect, transcriptomic and gene expression analyses revealed that S-dinotefuran caused stronger transcriptional disturbances , with upregulation of detoxification-related pathways, including cytochrome P450 metabolism, glutathione metabolism, and glycine-serine-threonine metabolism, with significant up-regulation of key detoxification genes (GPx CYP3A4 and CYP2) and suggesting that S-dinotefuran induced stronger oxidative stress and detoxification requirements. Although dinotefuran enantiomers had limited direct effects on soil microbial diversity, earthworm activity altered bacterial community composition, enhanced soil urease (UE) and catalase (CAT) activities and enriched beneficial bacterial groups, thereby improving degradation efficiency and buffering pesticide-induced ecological disturbances. This study emphasizes the importance of considering enantioselective effects when assessing the environmental risks of dinotefuran.

**Keywords**: Dinotefuran; *Eisenia foetida*; Microorganisms; Detoxification mechanisms; Enantioselectivity

# Rinsing tea reduces the health risk of neonicotinoids in the tea infusion

Rui Wang[1], Quan Zhang[1]

[1]Key Laboratory of Microbial Technology for Industrial Pollution Control of Zhejiang Province, College of Environment, Zhejiang University of Technology, Hangzhou, Zhejiang, 310032, China.

## Abstract (oral)

Neonicotinoid insecticides (neonics) are used extensively in agriculture because of its excellent insecticidal efficacy, yet its high-water solubility makes it susceptible to residues in water-based beverages such as tea infusions, posing a potential risk to public health. Nevertheless, the effects of rinsing as part of the Chinese tea ceremony on the residue of neonics in tea infusions have been rarely investigated. Herein, we collected 120 market-sourced tea samples, which consisted of green tea, white tea, yellow tea, oolong tea, black tea, and reprocessed tea (chrysanthemum tea, jasmine tea, clove tea and honeysuckle tea), and conducted multiple consecutive brews to analyze eight neonics. Neonics were detected in 97% of the teas, with concentrations ranging from n.d. to 552.3 μg $kg^{-1}$. The residue was higher in green and chrysanthemum teas, with acetamiprid (ACE) being the predominant neonics, showing mean concentrations (μg $kg^{-1}$) of 250.9±6.7 and 205.6±46.2, respectively. In contrast, dark tea exhibited the lowest neonics residues. Rinsing tea before brewing appropriately reduced neonics residues and exposure risk, with exposure risk reduction levels ranging from 12.18% to 37.42%. This study suggests that tea consumption may be the primary route of neonic intake for most tea drinkers. Studies have shown that rinsing the tea leaves before brewing and restricting the brewing time (no more than one hour) can reduce neonics. This study highlights neonics residues, transfer rate during brewing, and potential health risks in tea and tea infusion.

**Keywords**: Analytical chemistry, Insecticide, Transfer rates, Risk assessment

# Occurrence, distribution and ecological risks of antibiotic concentration in the surface water environment of Suzhou (China)

Feng Guo[1], Hu Zhao[1], Hongfei Yuan[1], Xianjing Song[1], Siwen Liu[1], Chenge Ma[1]

[1]National Research Center for Geoanalysis, Key Laboratory of Eco-Geochemistry, Ministry of Natural Resource

## Abstract (oral)

As a new type of environmental pollutant, antibiotic pollution has posed a serious threat to the security of the water ecosystem. Exploring the spatial heterogeneity driving mechanism and risk management has become a current research focus. In this study, Suzhou, a typical city in the Yangtze River Delta, was selected as the research object, and a multi-model coupling analysis framework was built by integrating the Geoweighted regression (GWR), GeoDetector and Sandwich interpolation models to systematically analyze the spatial differentiation, multi-source driving mechanism and ecological risk of antibiotics in water. The results show that: (1) A total of 13 antibiotics in 3 categories were detected in the study area, and sulfamethoxazole antibiotics (especially sulfamethoxazole SMX) dominated the study area (the detection rate accounted for 18.52%). The spatial distribution of their concentrations showed a radiating decreasing trend from the central urban area(Mean value: 21.37 ng $L^{-1}$) to the surrounding counties(Mean value: 10.74 ng $L^{-1}$), but a significant high value area was formed in Zhouzhuang Town, the intersection of Kunshan City and Wujiang City in the southeast, and the lower reaches of Changhu River in the north. (2) Through multi-source analysis, the study regions were divided into agricultural non-point source dominant area (northeast, $q=0.82$, $p<0.05$), medical point source impact area (central urban area, $q=0.74$, $p<0.05$), aquaculture intensive area (southern area, $q=0.86$, $p<0.05$) and composite pollution area (central area), revealing that the leading driving factors of each region were highly consistent with the characteristics of pollution sources, and the two factors interaction showed synergistic enhancement effect. The q value of interaction between pharmaceutical enterprises and other driving factors (such as population density and aquaculture) was generally >0.9, indicating a significant spatial leading role. (3) The assessment based on the ecological risk entropy method showed that roxithromycin (ROX) and clarithromycin (CTM) presented higher risk grade (RQs>1) in the detected sampling points, and the spatial difference of the multi-antibiotic joint risk index (RQsum) was significant (0.04-3.51). The northern region exhibited high risk aggregation (RQsum > 2.28). The comprehensive analysis method system, established in this study as "source analysis - driving mechanism – risk assessment," can be applied to urban watersheds.

**Keywords**: Antibiotics; Driving factors; Ecological risks

# Occurrence of antidepressants and their metabolites in urban sewage in Beijing based on high-performance liquid chromatography - tandem mass spectrometry

Qiaozhen Guo[1], Liping Liu[1], Jing Zhang[1], Bing Shao[1]

[1]Beijing Center for Disease Prevention and Control

**Abstract (poster)**

Depression is one of the most common psychological disorders, and it can lead to suicide in severe cases. World Health Organization (WHO) predicts that depression will become the leading factor in the global disease burden by 2030. Antidepressants are a class of psychoactive drugs that have significant therapeutic effects on the clinical symptoms of depression. Research has shown that antidepressants cannot be fully metabolized and absorbed by humans, ultimately resulting in the elimination of drug prototypes or metabolites from the body into wastewater. In recent years, the use of antidepressants has been increasing, and the concentration in water has risen from a few ng/L to as high as μg/L. Antidepressants have become a new worrying "pseudo-persistent" pollutant.

To establish a method for evaluating antidepressants and their metabolites in urban sewage by solid phase extraction-high performance liquid chromatography-tandem mass spectrometry (SPE-HPLC-MS/MS), the analytical conditions were chosen by optimizing parameters for mass spectrum, separation conditions for chromatography and pretreatment conditions. Water samples were enriched and purified by HLB solid-phase extraction, separated by C18 chromatographic column, and gradient elution was carried out with methanol and ammonium formic aqueous solution (pH=4) as mobile phase. Electrospray ionization source positive mode (ESI+) was used for detection, and multiple reaction monitoring (MRM) was used for determination. The concentration of the standard curve of 30 target substances ranged from 0.5 to 1000 ng $L^{-1}$. The correlation coefficients were 0.994-0.999. The detection limit was 0.02-19.2 ng $L^{-1}$, and the limit of quantification was 0.05-64 $L^{-1}$. Three concentration levels were spiked to the water for recovery evaluation; the average recovery was 70.2%-120%, with the RSD ranging from 0.4% to 15.4%, except for N-desmethylsertraline. A total of 14 antidepressant drugs and 2 metabolites were detected in 48 municipal sewage samples in Beijing by this method. The concentrations were ND (not detected) -1853 $L^{-1}$ in the positive samples, among which the concentrations of venlafaxine and its metabolite O-demethylvenlafaxine were 0.55-1853 $L^{-1}$ and ND~ 298 $L^{-1}$, respectively, that is, the highest detection rates of 100% and 97.9%, respectively. The detection concentrations of citalopram and its metabolite (+) N-desmethylcitalopram were ND~ 17 $L^{-1}$ and ND~ 8 $L^{-1}$, respectively, and the detection rates were 85.4% and 81.3%, respectively. The results demonstrated that the method is sensitive, efficient, and reliable, and could be used to simultaneously determine a variety of antidepressant drugs and their metabolites in urban sewage. These will provide methodological support for the evaluation of antidepressants.

**Keywords**: Antidepressants; SPE; HPLC-MS/MS; Sewage

# Adsorption behavior and enhanced removal effect of perfluorooctane sulfonate (PFOS) in solution by bamboo powder biochar

Yuxue Liu[1]

[1]State Key Laboratory for Quality and Safety of Agro-Products, Institute of Environment Resource Soil and Fertilizer, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China

## Abstract (poster)

Perfluorooctane sulfonate (PFOS) is an emerging organic pollutant prevalent in the environment. The high toxicity, bioaccumulation and environmental persistence of PFOS pose significant risks to ecosystems and human health, and remediation technologies are urgently needed. However, conventional treatment techniques have proven difficult, necessitating the development of more affordable alternatives to adsorbents. Biochar shows great potential as an inexpensive adsorbent for PFOS removal owing to its excellent pore structure, surface properties, and ability to generate persistent free radicals (PFRs). In this study, biochar is prepared from bamboo powder at 300, 500, and 700 °C (BP300, BP500, and BP700). BP500 showed a more developed pore structure, larger specific surface area, and higher PFR signals. The removal efficiency of PFOS on BP500 (49.45%) was superior to that on BP300 and BP700. The influence of environmental factors (biochar dosage, pH, kinetics, isotherms, and inorganic anions) on the adsorption behavior of PFOS was determined. The removal of PFOS increased at low pH, reaching 63.77% at pH 2, while the presence of inorganic anions in the solution inhibited PFOS removal by BP500. The presence of oxidants ($H_2O_2$ and $S_2O_8^{2-}$) alongside BP500 in the solution improved PFOS removal efficiency. The oxidant added to biochar could degrade PFOS, as evidenced by the detection of F-, and the removal and degradation rates increased with the oxidant dosage. This study provides a new perspective for analyzing the mechanism of PFOS removal by biochar. In the future, the industrial-scale application of bamboo biochar for contaminant removal must be strengthened..

**Keywords**: Emerging contaminants; PFASs; Carbon-based material; Adsorption behavior; Environmental remediation

# Effect-directed analysis of new effective pollutants based in $PM_{2.5}$

Zikang Li[1,2], Guangbo Qu[1,2,3,4]

[1]State Key Laboratory of Environmental Chemistry and Ecotoxicology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China
[2]University of Chinese Academy of Sciences, Beijing 100049, China
[3]School of Environment, Hangzhou Institute for Advanced Study, University of Chinese Academy of Sciences, Hangzhou 310000, China
[4]Key Laboratory of Environment Remediation and Ecological Health, Ministry of Education, College of Environmental and Resource Sciences, Zhejiang University, Hangzhou 310058, China

## Abstract (poster)

Combining the advances of biological assay, fractionation with chromatography, and mass spectrum analysis, effect-directed analysis (EDA) has emerged as a widely applied approach for identifying key toxicants in complex environmental samples. The samples collected from contaminated regions in this study were extracted using accelerated solvent extraction (ASE). The aryl hydrocarbon receptor (AhR) agonistic potency of the extracts was evaluated using a cell-based genetic reporter assay, which utilizes the luciferase reporter gene. Samples exhibiting high AhR agonistic activity were fractionated using an established fractionation protocol, which separates the complex mixture into discrete fractions based on chemical properties. These fractions were collected for chemical analysis to identify unknown aryl hydrocarbon receptor (AhR) agonists. The contributions of potent AhR agonists to adverse biological outcomes have been discussed. More fractionation methods are required to seek the source of measured toxicity induced by the extracts from real $PM_{2.5}$.

**Keywords**: Effect-Directed Analysis (EDA); Aryl Hydrocarbon Receptor (AhR); $PM_{2.5}$

# Paleoenvironmental characterization and historical trends of polycyclic aromatic hydrocarbons (PAHs) of Nutrias Lagoon, Uruguay

German Azcune[1], Laura del Puerto[2], Adriana Blasi[3], Carola Castiñeira[3], Laura Pérez[2], Andrés Pérez Parada[1], Laura Fornaro[1]

[1]Departamento de Desarrollo Tecnológico, Centro Universitario Regional Este, Universidad de la República, Uruguay
[2]Polo de Desarrollo Universitario "Aportes a la Gestión Territorial y Producción Responsable en la Región Este: Biodiversidad, Ambiente y Sociedad", Centro Universitario Regional Este, Universidad de la República, Uruguay
[3]CONICET - División de Mineralogía, Petrología y Sedimentología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Argentina

## Abstract (oral)

Concentrations of polycyclic aromatic hydrocarbons (PAHs) were assessed in a sediment core retrieved from Nutrias Lagoon, located within the Rocha Lagoon Protected Area along the SE Uruguayan coast. Using a 210Pb chronology, we reconstructed the historical accumulation of PAHs over the past 120 years (1895-2018). Our examination of dating, geochemical, and sedimentological data unveiled four main events, with minor instances in 1956±5 and 1964±4, and more significant occurrences in 1914±9 and 1997±2. Additionally, two prominent trend shifts were identified, one predating 1900 and the other in 1986±2. Before 1900, a dry spell was apparent, supported by all proxies, alongside a notable surge in heavy PAHs, likely attributed to fires during this arid period. Post-1986±2, a rise in sedimentation rates in the lagoon was observed, possibly due to increased rainfall. Also, the eutrophication of the lagoon over the years can be observed. Furthermore, a recent increase in PAH influx at the core's surface was linked to the construction of a nearby lagoon bridge and associated roadwork. Our findings suggest that atmospheric deposition constitutes the primary source of PAHs in the lagoon, offering insights into its recent environmental history and basin dynamics. This study establishes a critical baseline for future research in the region and facilitates the development of effective and sustainable environmental management strategies.

**Keywords**: Dating; Climatic shift; $^{210}$Pb; Paleolimnology; Pollution

# Emergent pollutants in a saline aquifer from an agricultural/semi-urban area in Mexico

Zayre I. González-Acevedo[1], Marco A. García-Zarate[2], Italia Pamela Flores-Lugo[3]

[1]Centro de Investigación Científica y de Educación Superior de Ensenada, Department of Geology, Baja California, México
[2]Centro de Investigación Científica y de Educación Superior de Ensenada, Department of Optics, Baja California, México
[3]Centro de Investigación Científica y de Educación Superior de Ensenada, Postgraduate Program on Earth Sciences, orientation on Environmental Geosciences, Baja California, México

## Abstract (oral)

The quality and availability of water for human consumption have become a pressing issue worldwide. This is particularly important in semi-arid regions, where climate change has aggravated the problem. The use of anthropogenic chemicals, classified as emerging pollutants, adds to the problem because they are not regulated and pose a potential threat to human and animal health. This pressing problem has not been widely studied in saline aquifers of agricultural Valleys, like the one we present here. In our work, we determined the presence and seasonal variability of faecal sterols, alkylphenols, pesticides (emerging pollutants), and nutrients in 35 wells used for both agricultural and human consumption during two seasons: dry and wet. We found that the mobilization of these pollutants in the saline aquifer we studied is highly dynamic, showing important differences in concentration and distribution of contaminants. It is essential to highlight that the wells destined for household use showed the highest variability. These wells were also where anthropogenic fecal sterols were detected with maximum concentrations of coprostanol (22.59 ng $L^{-1}$), cholestanol (25.36 ng $L^{-1}$), cholesterol (356.94 ng $L^{-1}$), epicoprostanol (14.55 ng $L^{-1}$), sitostanol (1.59 ng $L^{-1}$) as well as alkylphenols (octyphenol (34.93 mg $L^{-1}$) and nonylphenol (96.15 ng $L^{-1}$). Additionally, in agricultural and urban wells, we detected DDT (ranging from 0.06 to 28.79 ng $L^{-1}$) and organochlorine pesticides (ranging from 0.02 to 1.69 ng $L^{-1}$), as well as myclobutanil (ranging from 0.29 to 518.82 ng $L^{-1}$), which are considered modern pesticides. Nitrates presents also concentrations up to 9 times above international standards (10 mg $L^{-1}$), mainly during the dry season, in both the agricultural and urban areas. This work highlights the importance of measuring this type of pollutant in agricultural/semi-urban areas, where aquifers have been overexploited and locals have used septic tanks for decades, due to the potential effects on environmental and human health.

**Keywords**: Nutrients; Pesticides; Fecal sterols; Maneadero

# Source-specific fate analysis of antibiotics in the Fenhe River Basin

Ruimin Liu[1], Linfang Wang[2], Lu Liu[1]

[1]Beijing Normal University
[2]Shanxi Agriculture University

## Abstract (poster)

In the 20th century, the global use of antibiotics grew rapidly to prevent and treat bacterial infections in humans and promote animal growth in the livestock industry. However, this widespread use has raised significant concerns about ecological safety and human health. As the final destination for antibiotics, watershed environments, with their diverse media, play a key role in the migration and fate of these substances. This study focuses on 26 antibiotics in the Fenhe River Basin, investigating their source-specific fate across various environmental media and the dynamics of their equilibrium times. Results showed that the predicted environmental concentrations revealed that nearly 99% of antibiotics from different sources remained in the water phase, with azithromycin (AZM) contributing the largest proportion (99.9%) from livestock, pharmaceutical wastewater, and domestic sewage. The equilibrium time for antibiotics from pharmaceutical and sewage treatment plant wastewater was generally short, with 50% of antibiotics from these sources reaching equilibrium in less than one week. In contrast, antibiotics from livestock and poultry breeding wastewater had longer equilibrium times, with 56% of antibiotics taking more than 13 weeks to reach equilibrium. Furthermore, the equilibrium times varied significantly between different antibiotics.

**Keywords**: Antibiotics; Multimedia; Source-specific; Fugacity Model; River basin

# Risk assessment of ammonia in nationwide freshwater of Japan

Binle Lin[1], Naoko Tobari[1]

[1]AIST, 1-3-1 Kasumigaseki, Chiyoda-ku, Tokyo 100-8921 Japan

**Abstract (poster)**

Ammonia has been seen as a promising carbon-free hydrogen energy. Considering its historical role as a fertilizer and its future potential as a fuel, ammonia may profoundly impact modern society. Society needs to grasp the current situation of ammonia in freshwater systems because ammonia exhibits substantial toxicity to fish and other aquatic life. However, its concentration of free ammonia ($NH_3$-N) remains unclear in the nationwide freshwater systems of Japan. Two kinds of historical monitoring data ($NH_4$-N) were accumulated and used to analyze the water's free ammonia concentration ($NH_3$-N). The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has been monitoring ammonium (NH4-N) concentrations at 2,429 sites in 109 First Class Rivers across Japan, while The Ministry of Environment (MOE) has been monitoring the $NH_4$-N concentrations in water at around 75 monitoring sites in 47 prefectures, mainly at urban rivers managed by local governments, lakes, ponds, and some sea areas. The water pH and temperature were required to calculate the free ammonia concentration ($NH_3$-N) from the monitored $NH_4$-N concentrations. The spatiotemporal variations in the concentration of $NH_3$-N in the monitoring sites of the nationwide water systems were first revealed. These results show that the current situation of the free ammonia concentration in Japan's nationwide freshwater system mainly originated from agricultural use and may provide a valuable message about the future use of ammonia as energy.

**Keywords**: Ammonia; Aquatic Toxicity; Exposure; Risk

# Analysis of antibiotics content and sources in organic agricultural soils

Wang Linfang[1], Shen Jinke[1], Liu Ruimin[2]

[1]Shanxi Agricultural University
[2]Beijing Normal University

## Abstract (poster)

Antibiotics, which promote growth and exhibit therapeutic effects, are widely used in the livestock and aquaculture industries. In China, livestock farming consumes approximately 84,000 tons of antibiotics annually, accounting for 52% of total antibiotic usage. After being administered to livestock, only a portion of these antibiotics are metabolized, while 30–90% are excreted in urine and feces as parent compounds or metabolites. While substituting chemical fertilizers with livestock manure for soil amendment enhances water retention, increases organic matter content, improves soil structure, and provides comprehensive nutrients for plants, it also introduces substantial amounts of antibiotics into farmland soils, making them a significant reservoir of antibiotics.

This study focused on a typical organic agricultural region. Through sampling and analysis, 22 categories of antibiotics were detected in the soil, with total concentrations ranging from 74.124 to 2,271.748 ng $mL^{-1}$. The dominant antibiotic categories were tetracyclines (TCs) at 1,041.21 ng $mL^{-1}$, quinolones (QNs) at 85.01 ng $mL^{-1}$, and macrolides (MLs) at 36.04 ng $mL^{-1}$. Source apportionment using the Positive Matrix Factorization (PMF) model revealed that antibiotics in farmland soil primarily originated from swine manure (41.26%) and wastewater irrigation (28.77%), followed by poultry manure (11.66%) and cattle manure (13.07%), with atmospheric deposition contributing minimally (5.24%).

**Keywords**: Antibiotics; Sources; PMF; Organic agricultural soils

# Arbuscular mycorrhizal fungus alleviates charged nanoplastics stress in the host plant via enhanced defence-related gene expressions and hyphal capture

Hui Li[1], Han Hao Li[1], Xun Wen Chen[1]

[1]Guangdong Provincial Research Centre for Environment Pollution Control and Remediation Materials, Department of Ecology, College of Life Science and Technology, Jinan University, Guangzhou, 510632, China

## Abstract (poster)

Contamination of small-sized plastics is recognized as a factor of global change. Nanoplastics (NPs) can readily enter organisms and pose significant ecological risks. *Arbuscular mycorrhizal* (AM) fungi, the most widespread plant symbiotic partners, play a pivotal role in enhancing host fitness and ecosystem functioning. Given their well-documented capacity to alleviate abiotic stresses, it remains unclear how AM fungi modulate plant responses to NPs toxicity, representing a critical knowledge gap in plant-environment interactions. Here, we investigated how the AM fungus *Rhizophagus irregularis* modulates NP behavior and alleviates phytotoxicity in lettuce (*Lactuca sativa*). Using three types of polystyrene NPs (~30 nm diameter; positively charged PS-NH2 [+45.2 mV], uncharged PS [−4.7 mV], and negatively charged PS-$SO_3H$ [−54.2 mV]) at 5 g $kg^{-1}$ soil concentration over 86 days, we found that R. irregularis increased lettuce shoot biomass by 25–100% under charged NP exposure compared to non-mycorrhizal controls, though no enhancement occurred without NPs. The stress alleviation was attributed to: (1) upregulation of defence-related genes (phytohormone signalling, cell wall metabolism, and oxidant scavenging), and (2) hyphal capture of NPs in a root-organ system (50 mg L-1 NPs, 28-day exposure). Fluorescence labelling revealed NPs localised at hyphal cell walls, membranes, and spore walls, with subsequent delivery to root epidermis, cortex, and stele. Hyphal exudates aggregated positively charged NPs (up to 5000 nm), reducing their uptake.

This work demonstrates the critical roles of AM fungus in regulating NP behaviors and provides a potential strategy for NP risk mitigation in terrestrial ecosystems. Consequent NP-induced ecological impacts due to the affected AM fungi require further attention.

**Keywords**: Lettuce; Nanoplastics; Arbuscular mycorrhizal fungi; Hyphae; Capture; Toxicity

# Environmental factors influencing the dynamics of bacterial resistance to antibiotics (BRA) in a small rural watershed in France

Jean M.F. Martins[1], Lorenzo Spadini[1], Guillaume Nord[1], Agnès Richaume[2], Thibault Meyer[2], Cédric Legout[1], Armelle Crouzet[1], Céline Duwig[1], Abigail Delort[2], Pauline Defour[2], Sabine Favre-Bonté[2], Sylvie Nazaret[2]

[1]Univ. Grenoble Alpes, CNRS, IRD, INRAE, G-INP, IGE (UMR 5001), 38000 Grenoble, France.
[2]Univ. Lyon 1, CNRS, INRAE, LEM (UMR 5557), 69622 Villeurbanne, France.

## Abstract (oral)

Bacterial resistance to antibiotics (BRA) represents one of the major threats to human health. A better understanding of the dynamics of BRA in the environment remains a major challenge. This study aimed to assess the dynamics of BRA in soil and surface water of a small arid rural watershed in France. Applying an original and transposable hydrological and microbiological approach, we determined the levels and dynamics of six major genes, used as indicators of antibiotic resistance, in the watershed under all hydrological conditions over 30 months. Digital PCR analysis of water and soil samples revealed the systematic presence of resistance genes (in particular sul1, sul2, tetW, intI1), which are primarily linked to human activities (sewage treatment plants, livestock farming, urbanization). The blaCTX-M resistance gene has not been detected, probably because this antibiotic is still very new. Although other factors, such as direct discharges or the presence of metals, appear to play a significant role, flooding strongly amplifies antibiotic resistance gene concentrations, indicating a potentially substantial contribution from surface runoff phenomena in the catchment. Strong links were observed between trace metals (e.g. copper, zinc...) and the abundance of resistance genes, indicating co-selection potential. In soils, areas close to human activities concentrate more resistance genes (potentially leachable during floods), but with little effect on nitrifying activity, suggesting no effect on soil functioning. The study shows that even in rural, less urbanized areas, human activities and land use contribute to the spread of antibiotic resistance, thus justifying the need for environmental monitoring of antibiotic resistance.

**Keywords**: Bacterial resistance to antibiotics (BRA); Antibiotic resistance genes; Water geochemistry; Hydrology; Watershed; Soil nitrification.

MEDGEO 25 ISEG

# theme 3

## geochemical mapping, human health impacts and environmental remediation

# Evaluation of the role of water-rock interactions in developing nature-based solutions to ammonia-polluted groundwater

M. A. Aurora Armienta[1], Angélica M. Castañeda[2], J. Iván Morales-Arredondo[1], Alejandra Aguayo1, Olivia Cruz[1], Omar Neri[1], Graciela Herrera-Zamarrón[1]

[1]Universidad Nacional Autonoma de Mexico, Instituto de Geofisica
[2]Universidad Nacional Autonoma de Mexico, Facultad de Quimica

## Abstract (oral)

The presence of nitrogen species is a worldwide groundwater pollution problem. Nitrates are the most common nitrogen species, but ammonia also occurs in some aquifers. While ammonia does not represent a health risk through water intake at typical levels in drinking water, acidosis and osteoporosis have been observed in animals resulting from chronic ingestion. In addition, ammonia may affect the quality of potable water by reducing the disinfection efficacy and the formation of carcinogenic sub-products through its reaction with chlorine. In Mexico, the drinking water standard is 0.5 mg/L N-NH3. Concentrations higher than the allowable level have been detected in some wells used as potable water sources in Mexico City. We are studying methods to eliminate ammonia from polluted groundwater by applying nature-based solutions. The knowledge of ammonia interaction with the rocks in the aquifer is an essential part of this study. To this aim, we performed batch experiments with rocks collected at various depths (up to 286 m deep) from two wells and water solutions with various ammonia concentrations. The rock types included conglomerates, andesites, basalts, tuffs, sands, and gravels. Rock samples selected from depth ranges showing distinct visible characteristics were crushed and sieved at various particle sizes (<0.063 cm, 0.063-0.125 cm, <0.125 cm). After two hours of agitation, centrifugation, and filtration, the concentration of ammonia remaining in the solution was analyzed by colorimetry (Hanna Hl715). All the tested rocks retained ammonia (44 to 90%), but differences were observed in the rocks, particle size, and depths. The highest retention was achieved with the smallest size for all the experiments. Gravels and sand presented the lowest ammonia removal, while tuffs, argillaceous andesitic and basaltic rocks (collected from one of the wells at 214 to 216 cm depth) had the highest removal. Different retention trends were observed between both wells related to their lithology. Water-rock interaction must thus be considered when developing the procedure to remove ammonia from groundwater. Further experiments are currently being conducted to evaluate the reversibility of the retention. This information will be crucial to determining the rock matrix's role in ammonia mobilization in the polluted groundwater and its possible influence on the options for aquifer restoration.

**Keywords**: Ammonia; Groundwater; Nature-Based Solutions; Rocks, Restoration

# EU Soil Monitoring Law and Medical Geology

Chaosheng Zhang[1]

[1]International Network for Environment and Health (INEH), School of Geography, Archaeology and Irish Studies, University of Galway, Galway H91 CF50, Ireland

## Abstract (oral)

The EU Action Plan 'Towards Zero Pollution for Air, Water and Soil' and the forthcoming 'Soil Monitoring Law' aim to reduce pollution to levels no longer harmful to health and natural ecosystems by 2050. However, due to spatial heterogeneity, identifying the precise sources and status of soil pollution remains challenging.

Medical geology, the science exploring the relationship between geological factors and health issues in humans, animals, and plants, characterizes geological processes, agents, and the dispersal of geological materials and their effects on populations. Spatial heterogeneity is a significant feature of geological materials and processes.

Spatial heterogeneity exists at various scales, from global to microscale, and is influenced by different controlling factors. Big data presents challenges and opportunities for advancing local thinking in medical geology. This study explores various techniques: local statistics calculate descriptive statistics at the local level using moving windows; the local coefficient of variation reveals spatial variation of nickel (Ni) in Northern Ireland soils; Local Moran's I identifies spatial outliers and clusters of lead (Pb) in Galway soils; Getis-Ord Gi* hot spot analysis identifies high-value hot spots and low-value cool spots of total organic carbon (TOC) and pH in European soils; and local correlation coefficients reveal spatially varying relationships between lead (Pb) and aluminum (Al) in London soils, as well as between soil organic carbon (SOC) and elevation in Ireland, showing positive relationships in blanket peat areas and negative in basin peat areas.

The EU 'Soil Monitoring Law' offers new opportunities for research in medical geology. Recognizing spatial heterogeneity as an environmental fact, 'big data' enables a focus on local-level details. A shift from global to local thinking is essential for data analytics in medical geology.

**Keywords**: Spatial Thinking; Spatial Heterogeneity; Soil Monitoring Law; Medical Geology; GIS

# Groundwater quality challenges in Salto, Uruguay´s agricultural regions

Elena M. Alvareda Migliaro[1], Andrés Saracho[2], Mercedes Gelós[3], Lucia Pareja[4], Gonzalo Medina[2], Sofía da Rocha[2], Rafael Navas[2]

[1]Departamento del Agua, Centro Universitario Regional Litoral Norte, Universidad de la República, Rivera 1350, Salto, Uruguay. Programa de Desarrollo de las Ciencias Básicas (PEDECIBA) área Química. Isidoro de María 1614 piso 6. Montevideo, Uruguay.
[2]Departamento del Agua, Centro Universitario Regional Litoral Norte, Universidad de la República, Rivera 1350, Salto, Uruguay
[3]Dirección Nacional de Calidad y Evaluación Ambiental, Ministerio de Ambiente, Montevideo, Uruguay
[4]Departamento de Química del Litoral, Centro Universitario Regional Litoral Norte, Universidad de la República, JW9W+MMR, 60000 Paysandú, Paysandú Uruguay.. Programa de Desarrollo de las Ciencias Básicas (PEDECIBA) área Química. Isidoro de María 1614 piso

## Abstract (oral)

In recent decades, the aquifers in Salto, Uruguay, have been used for human consumption without prior treatment, as they are considered a safe source of drinking water. The San Antonio Creek (SAC) basin, located in Salto, is one of the most important citrus production areas in Uruguay. However, agricultural expansion and increased use of agrochemicals across the basin have raised concerns about potential impacts on water quality. Given that groundwater serves as a crucial source of drinking water for local communities, assessing its quality is essential to safeguarding public health. The study area is a region characterized by intensive horticulture in greenhouses (GH), open-field (OP) agriculture, and citrus farming. Irrigation plays a crucial role in citrus crop production, particularly in regions with irregular rainfall and recurrent droughts. Beyond sustaining agricultural yields, proper irrigation management is essential for maintaining soil nutrient balance. However, background in that area shown that excessive water use for irrigation can significantly influence groundwater resources and their connection with surface water systems. Over-extraction of groundwater can lead to lower river and wetland levels, while surface water infiltration contributes to aquifer recharge. Ignoring these interactions can lead to severe environmental consequences, including aquifer depletion, reduced base flows in rivers, and deterioration of water quality. Previous studies conducted by Alvareda et al (2019) in the same area found that total phosphorus levels (50.0 - 178.5 μg $L^{-1}$) exceeded the maximum allowable limit of 25 μg $L^{-1}$ for irrigation water, as established by national regulations (Decree 253/79). A SWAT+gwflow model implemented with 24 sub-basins, considering surface water quality parameters such as nitrate ($NO_3^-$), ammonia ($NH_4^+$), total phosphorus (P), total suspended solids (TSS) and pesticides. 10 sites of SAC were monitored to evaluate water quality for irrigation uses by the Standard Methods for Examining Water and Wastewater. Saracho et al. (2024) noted that irrigation expansion reduces the groundwater head across the watershed, leading to higher rates of boundary inflow to the aquifer, which exhibits the most rapid connection to the SAC. This study analyzes the specific effects of intensive agricultural practices on surface and groundwater analyzing nitrate patterns. Surface water and groundwater could be closely linked, meaning that changes in one can directly influence the other. Results indicate the impact of transitioning from rain-fed to irrigated citrus cultivation through groundwater extraction for irrigation. Areas with high nitrate concentrations in groundwater expand with the irrigation expansion, likely due to greater nitrate leaching, particularly from open-field horticulture. On the other hand, other sources of nitrates in groundwater are related to leaks from septic tanks in rural households. Understanding these shreds of evidence is essential for developing sustainable water use strategies that balance agricultural productivity with the conservation of water resources and the protection of drinking water quality.

**Keywords**: Water quality; Irrigation model; Drinking water; Human health; Uruguay

# Evaluation of groundwater resources degradation at Algarve Basin (South Portugal) in the context of climate change adaptation: natural versus human impacts

Paula M. Carreira[1], Dina Nunes[1], Pedro Valério[1], José Manuel Marques[2], Maria Orquídia Neves[2]

[1]Centro de Ciências e Tecnologias Nucleares (C2TN), Departamento de Ciências e Engenharia Nuclear (DECN), Instituto Superior Técnico, Universidade de Lisboa
[2]Centro de Recursos Naturais e Ambiente (CERENA), Departamento de Engenharia de Recursos Minerais e Energéticos (DER), Instituto Superior Técnico, Universidade de Lisboa

## Abstract (oral)

The Algarve basin covers an area of 3,837 km² and has a population of over 300,000 inhabitants. Groundwater resources in this basin are over-exploited to meet the demands of human consumption, agriculture and tourism. In addition, shallow aquifers, particularly, are affected by continuous inputs of fertilizers (nitrates), pesticides and pharmaceutical compounds. At the same time, there is strong evidence that climate change will continue to alter the hydrological cycle, leading to drying trends and an increased risk of water scarcity, which can be disrupted by extreme events of heavy precipitation. A study was initiated within the framework of the WATER4MED project, whose main objective is to achieve sustainable and effective management of water resources in the Mediterranean region, specifically in the Algarve Basin (Faro-Tavira area). Evidence that climate change has already begun can be seen in the trends toward lower effective recharge rates throughout the Algarve region, reflected in an increased risk of drought and aridity. The main objective of this research is to identify and delimit groundwater salinization (marine intrusion vs. dissolution of evaporite minerals vs. agricultural practices) using chemical and nuclear analytical techniques. Three groundwater sampling campaigns were conducted, collecting samples from over 40 sites for isotopic and physicochemical analyses. The isotopic composition of the groundwater samples ranges between -4.83 ‰ and -0.40 ‰ in $\delta^{18}O$ (vs. V-SMOW) and between -27.7 ‰ and -6.46 ‰ in $\delta^{2}H$ (vs. V-SMOW). The groundwater average isotopic composition was used for the calculation of the freshwater-seawater mixing line and the percentage of mixture. The $^{3}H$ content was determined with electrolytic enrichment followed by emission counting by a liquid scintillation counter. The values obtained ranged from non-detect to 1.9 ± 0.6 TU. The main ions were only available in the water samples taken during the first sampling campaign. Field parameters, such as electrical conductivity (EC), pH, temperature, and Eh, were measured in situ. The EC of the groundwater samples ranges between 500 and 42,000 µS $cm^{-1}$. Hydrochemistry highlights the presence of phenomena that modify the chemical composition, i.e., ion exchange mechanisms with sodium release and calcium adsorption. In the $Cl/SO_4$ vs. Cl, Na/Cl vs. Cl, and Na vs. Cl diagrams, a deviation from the chemical evolution that is "characteristic" of the marine intrusion mechanisms can be observed. The stable isotope content enabled the identification of three main processes responsible for the degradation of water resources: marine intrusion, recycling and evaporation associated with agricultural practices, and water-rock interaction mechanisms. The highest degree of salinization was observed in borehole 610/254 (EC with a seawater presence of 30 %, while using $\delta^{18}O$ the mixing is 33.9 %). However, different mixture values were obtained when evaporite minerals were dissolved, e.g., at Fuseta spring. The $^{3}H$ content in the groundwater samples indicates active recharge of the systems and relatively modern waters. Tracing the natural and anthropogenic origin of pollutants is of paramount importance for science-society cooperation. This will promote social participation that can help minimize pollution in rural and urban areas.

**Keywords**: Groundwater degradation; Salinization; Agriculture; Environmental isotopes

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# Chelatin-iron oxide nanoparticles for sustainable arsenic remediation in rice fields

Maria Paula Cabral Campello[1], Bernardo Monteiro[2], Clemente Breti[3], Demetrio Milea[4], Dina Nunes[1], Laura C. J. Pereira[1], Rosita Cappai[5], Sofia Gama[1], Paula M. Carreira[1]

[1]Centro de Ciências e Tecnologias Nucleares (C2TN), Departamento de Ciências e Engenharia Nuclear (DECN), Instituto Superior Técnico
[2]Instituto de Plasmas e Fusão Nuclear (IPFN), Instituto Superior Técnico, Universidade de Lisboa
[3]Dipartimento di Scienze Chimiche, Biologiche, Farmaceutiche e Ambientali, Università di Messina, Italy
[4]Dipartimento di Chimica Inorganica, Chimica Analitica e Chimica Fisica (CHIBIOFARAM), Università di Messina, Italy
[5]Università degli Studi di Sassari, Italy

## Abstract (oral)

The degradation of water quality due to natural processes and human activities raises concerns about arsenic contamination, a major environmental and health issue. Modern agriculture, while increasing productivity, contributes to soil and water pollution, particularly by releasing toxic metals like arsenic. This is especially critical in rice cultivation, a staple for over half of the global population. Portugal stands out in Europe for its high per capita rice production and consumption, with 31.67% of the mainland used for agriculture, including 6.76% for irrigated farming. Irrigation quality is vital for crop health and environmental safety; however, arsenic contamination often stems from agricultural and natural inputs. One of the problems associated with rice plantations is that in many rural areas, drinking and domestic water supplies are drawn from shallow aquifers under agricultural land, and the quality of these water resources can be affected by agrochemicals (nitrate fertilizers and pesticides). In addition to this anthropogenic pollution, the bioaccumulation of toxic elements in rice fields is a major environmental concern, as rice is the primary food for billions of people. Understanding arsenic toxicity and mobility is crucial for risk mitigation. In aqueous solutions, arsenic exists mainly as arsenite (AsIII) and arsenate (AsV), with AsIII being more toxic and readily absorbed by plant roots. In contrast, AsV is taken up through phosphate transporters and reduced to AsIII in root cells. Arsenite binds to sulfhydryl groups in proteins, altering their function. However, plants and soils utilise this property for detoxification through thiol-rich compounds, such as glutathione (GSH) and phytochelatins (PCs), which complex with arsenite, thereby reducing its phytotoxicity. Monitoring arsenic levels in soils, irrigation water, and crops is crucial for mitigating its adverse effects. Nanotechnology offers promising solutions for arsenic remediation. Iron oxide-based nanoparticles stand out among nanomaterials due to their strong adsorption capacity and magnetic properties, which allow for easy removal from water. In this study, superparamagnetic iron nanoparticles, both bare and coated with GSH and PC derivatives, will be synthesized and optimized to improve arsenic adsorption. Speciation studies will be conducted using real chemical data to assess their efficiency in removing arsenic and other heavy metals and metalloids (As, Cd, Pb, Mn) in the rice paddy water system. The emphasis will be on As, but without excluding other toxic metals. The experiments will be carried out in the rice fields of COTArroz (Salvaterra de Magos, Portugal), where water and soil samples are being analyzed throughout the rice growth cycle to monitor arsenic dynamics. A remediation methodology based on the extraction of As through its adsorption on magnetic GSH/PCs type nanoparticles will be tested, followed by the regeneration and reuse of the nanoparticles to determine the ideal conditions for the adsorption of As(III/V) ions. The ultimate goal is to develop a sustainable remediation strategy for arsenic and heavy metals in natural water systems, particularly rice fields. By integrating chemical speciation modeling with field and laboratory experiments, the study aims to define optimal conditions for arsenic adsorption onto functionalized nanoparticles while ensuring their regeneration and reuse. Beyond its application in rice field water, this novel approach offers a scalable solution for heavy metal remediation in other aquatic environments. Reusing magnetic iron nanoparticles will improve water quality and reduce economic costs, contributing to environmental sustainability.

**Keywords**: Magnetic iron nanoparticles; Environmental Remediation; Rice Fields; Heavy Metals

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# Elemental distribution in groundwater: Implications for neurodegenerative disease prevalence in Sweden

Katelyn M.A. Mellgren[1], Sarah Conrad[1], Lina Hällström[1], Lena Alakangas[1]

[1]Luleå University of Technology Department of Applied Geochemistry

## Abstract (oral)

Groundwater is a vital resource estimated to account for approximately 50% of drinking water in Sweden (Barthel et al., 2021). Groundwater quality is affected by natural and anthropogenic processes and can strongly impact the health of humans. Elevated concentrations of metals (Al, Cd, Cu, Fe, Mn, Pb, and Zn) are linked to the development or progression of neurodegenerative diseases (NDDs), including multiple sclerosis (MS) and Parkinson's disease (PD) (Cabral Pinto et al., 2018; Cicero et al., 2017, Kissani et al., 2020; Lucchini et al., 2007). Exposure to these metals can occur through various mediums, but groundwater has not yet been discussed as a potential pathway for heavy metal exposure in relation to NDDs (Irvine et al., 1989; Verma & Dwivedi, 2013). The main objectives of this study were to enhance the understanding of elemental distribution within groundwater and to investigate the potential correlation between groundwater metal concentrations and MS and PD disease prevalence on a regional scale in Sweden. Groundwater mapping was performed using open-access groundwater data from the Geological Survey of Sweden. Disease prevalence regressions were conducted based on population-weighted elemental exposure, which accounts for elemental concentrations in inhabited areas to better estimate actual population exposure. Results from groundwater mapping indicate the presence of several elemental hotspots with elevated concentrations of Cd, Cu, Pb, and Zn, which are representative of anthropogenic pollution events, including fire drill sites and historic mining sites. Results from the disease prevalence regression showed a weak positive correlation between MS and Zn plus electrical conductivity ($R2 = 0.342$, $p = 0.008$). In contrast, for PD a weak correlation is present between Cu, Zn, and electrical conductivity ($R2 = 0.428$, $p = 0.021$). While these elements were most correlated to the disease prevalence, Cd and Pb also displayed weak correlations. Their potential role in these diseases should not be discounted, as multielement exposure could play an important role in NDD development. Al, Fe, and Mn did not correlate significantly with NDD prevalence rates. These correlations suggest that NDDs could develop based on the groundwater quality in areas of residence. In the next step, higher-resolution health data will be used to investigate the potential linkages between Cu, Cd, Pb, and Zn and NDD prevalence further.

**Keywords**: Groundwater; Elemental distribution; Neurodegenerative disease

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# Preliminary study on wildfire intensity and ecotoxicological screening of wildfire ash (North Attica, Greece)

Dimitrios Alexakis[1], Isabel Campos[2], Nelson Abrantes[3], Dimitra Gamvroula[4]

[1]Laboratory of Geoenvironmental Science and Environmental Quality Assurance, Department of Civil Engineering, School of Engineering, University of West Attica
[2]CESAM and Department of Environment and Planning, University of Aveiro, Aveiro, Portugal
[3]CESAM and Department of Biology, University of Aveiro, Aveiro, Portugal
[4]Laboratory of Geoenvironmental Science and Environmental Quality Assurance, Department of Civil Engineering, School of Engineering, University of West Attica

## Abstract (oral)

Predicted climate warming is a major driver of the dramatic increase in wildfire events worldwide. Wildfires represent a major global disturbance to forests, posing significant threats to life, human property, and natural resources. These impacts extend beyond the burned areas, affecting adjacent aquatic ecosystems as well. Wildfires play a crucial role in that they are primarily bound to ash in producing and mobilising contaminants, which are mainly bound to ash. These contaminants can be transported to downstream water bodies through post-fire runoff. Transferring inorganic and organic substances from wildfire ash into the water-soil-sediment system is critical because it may subsequently threaten ecological receptors and ecosystems.

Composite ash samples were collected immediately after a forest fire occurred within the boundary of the drainage basin of Marathon Lake to study the effects of the ash-laden runoff from burnt areas on water quality (North Attica, Greece). Marathon Lake, also known as the Marathon Reservoir, is an artificial water supply reservoir created by constructing the Marathon Dam at the confluence of two streams adjacent to Marathon, Greece. Marathon reservoir served as the principal water source for Athens from its inception in 1931 until 1959; nowadays, the reservoir functions as a supplementary source for the water delivery system of the wider Attica region and as a principal regulating reservoir. Field observations and a macroscopic approach were used to determine the wildfire intensity at each sampling site. During combustion, the estimated temperature in the wildfire-impacted area varied between 180°C and 420°C. An ecotoxicological screening was conducted on three types of ash (ash from unknown vegetation, pinus trees and waste material) using the producer Lemna minor as a test organism to assess growth inhibition.

**Keywords**: Wildfire impacts; Ash; Ecotoxicity; North Attica

# Estimation of nationwide drinking water fluoride exposure at address level in Denmark, 1980-2022

Kirstine H. Wodschow[1], Denitza D. Voutchkova[2], Birgitte Hansen[2], Annette Kjær Ersbøll[1]

[1]The National Institute of Public Health, University of Southern Denmark, Denmark
[2]Geological Survey of Denmark and Greenland, Denmark

**Abstract (poster)**

Fluoride occurs naturally in groundwater-based drinking water. Furthermore, low fluoride concentration is added to drinking water in some countries to prevent tooth decay. However, a negative association between exposure to even low fluoride concentrations and cognitive development has been found in recent epidemiological studies, though, e.g. lack of confounder adjustment and selecting study participants based on exposure group may have increased the association. A nationwide study population, well-studied exposure and the possibility of adjusting for risk factors at an individual level can reduce bias in future studies of the association between exposure to low fluoride concentrations in drinking water and cognitive development.

Therefore, our study aimed to estimate residential exposure to fluoride in drinking water in Denmark for the period 1980-2022 and investigate the temporal residential exposure coverage and geographical variation.

The study included nationwide groundwater-based drinking water data from 1980 to 2022, as well as historical and current water supply areas (WSAs), and residential addresses. First, a set of selection criteria was defined to prepare a clean dataset of fluoride analyses measured at public waterworks. Second, a yearly mean fluoride concentration was estimated at each WSA, taking into account water abstraction at the waterworks and using interpolation for years without measurements. Third, fluoride concentrations at the WSA level were assigned to addresses by spatial joint.

The cleaned fluoride drinking water data included 149,416 fluoride analyses, measured at 4,109 waterworks and covering 3,621 WSAs. Annual mean drinking water concentration at WSA level ranged from 0.003 to 7.1 mg $L^{-1}$ (mean 0.32 mg $L^{-1}$; median 0.22 mg $L^{-1}$). Fluoride exposure was assigned to 2,537,112 addresses with a temporal coverage ranging from one to 43 years.

Overall, the national fluoride concentration level in drinking water was stable. The highest exposure coverage was from the start of the 1990s onwards, where fluoride exposure was assigned to more than 95% of the addresses. Geographical variation was observed, with the lowest concentrations in western Denmark and the highest concentrations in smaller areas in the southeastern part of Denmark. In future epidemiological studies, this geographical distribution of fluoride in drinking water should be carefully considered in relation to the geographical distribution of possible risk factors, e.g. socioeconomic position.

**Keywords**: Fluoride; Drinking water; Exposure;

# Soil geochemistry and human health risk assessment using human tissues and fluids on Sal Island (Cape Verde)

Luísa Diniz[1], Gelson Carlos[2], Carmelita Miranda[3], João Pedro Cruz[1], Agostinho Almeida[3], Eduardo Ferreira da Silva[1], Marina Cabral Pinto[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal
[2]National Agency for Oil, Gas and Biofuels Angola
[3]LAVQ/REQUIMTE, Faculdade de Farmácia da Universidade do Porto
[4]Faculdade de Farmácia da Universidade do Porto. R. de Jorge de Viterbo Ferreira 228, 4050-313 Porto

## Abstract (poster)

Geochemical mapping is the foundational knowledge required to determine the concentrations of various chemical elements, particularly potentially toxic elements (PTEs), and to identify potentially hazardous regions of the planet. Various natural activities, such as volcanoes and soil erosion, can contribute to pollution. Therefore, this study provides geochemical distribution maps of the soil across the entire island of Sal (Cape Verde archipelago), as a basis for assessing ecological and human health risks, following the structure of the IGCP 259 project.

The geochemical soil maps strongly correlate with the island's geological features. Baseline values of Ba, Co, Ni, and V exceed international agricultural and residential use guidelines. Arsenic (As) levels in soils near the airport and on the Old Eruptive Complex show a high ecological risk potential factor. Still, whether these high levels have a geogenic (natural) or anthropogenic (human-made) origin is unclear.

Risk indices were calculated for both children and adults. The risk index below 1 obtained for children indicates a potential non-carcinogenic risk from elements such as Co, Cr, and Mn. High levels of Cr, Co, and Mn are present in soils from several formations, including Quaternary sediments, Monte Grande-Pedra Lume, and the Old Complex, suggesting a geogenic source. The calculated risk indices do not indicate a potential non-carcinogenic risk for adults. Cancer risk was also calculated for exposure to As, Cd, Cr, and Ni; however, the results are below the target carcinogenic risk threshold, indicating no risk. However, although less prevalent, elevated concentrations of Cr in specific soil samples suggest a potential carcinogenic risk for adults.

Evidence from studies suggests that both exposure to non-essential metals and dysregulation of essential metal levels play a significant role in the pathogenesis of neurodegenerative diseases. Neuropsychological evaluation is a crucial tool for identifying cognitive deficits associated with neurotoxic exposure, as is the use of human tissue or fluid samples for biomonitoring, which provides a valid measure of long-term exposure to PTEs. Trace chemical elements were analyzed and determined in inhabitants' hair, nails, blood, serum, and urine, identifying deviations from non-harmful levels. Simple correlation analyses were conducted, suggesting a relationship between the concentrations of potentially toxic elements in the human body and neuropsychological assessment, for example, between MMSE and MoCA scores and chemical elements such as Li, Rb, Sr, Cs, Ba, and Hg. Diverse statistical methods are also presented, identifying other correlations between PTEs and neuropsychological evaluation in elderly individuals residing on the island of Sal.

**Keywords**: Geochemical mapping; Potential toxic elements; Soil contamination; Ecological and human health risk; Biomonitoring; Neuropsychological assessment

# Lithium and associated elements around the Barroso Mine (Portugal): a baseline assessment for future monitoring

Susana Jesus[1], Marta Ventura[1,2], Ricardo Assunção[1,3], Sandra Gueifão, Inês Delgado, Andreia Rego,Ana Cláudia, Susana Santiago[1], Marta Martins[2], Orquídia Neves[4], Inês Coelho[1]

[1]Department of Food and Nutrition, National Institute of Health Doutor Ricardo Jorge (INSA, IP), Lisbon, Portugal
[2]MARE - Marine and Environmental Sciences Centre, ARNET - Aquatic Research Network Associate Laboratory, NOVA School of Science and Technology, NOVA University Lisbon, Caparica, Portugal
[3]Egas Moniz Center for Interdisciplinary Research (CiiEM), Egas Moniz School of Health & Science, Caparica, Almada, Portugal
[4]CERENA (Centro de Recursos Naturais e Ambiente), DER (Department of Mineral and Energy Resources Engineering), Instituto Superior Técnico, University of Lisbon, Portugal

## Abstract (oral)

The shift towards green energy is boosting the demand for lithium (Li) extraction; however, its supply faces environmental and health concerns. This study aims to characterize the concentration of Li and other elements in environmental and food samples collected from two adjacent locations near the future Barroso mine and perform an initial exposure and risk assessment for the local populations. The sampling plan considered the populations nearest to the Barroso mine concession and its intended second expansion. Samples were collected from 24 subsistence farms in the mine area's east and northwest villages. Site A (SA) gathers the eastern villages of Covas do Barroso, Romaínho, and Muro, while Site B (SB) integrates the northwestern villages of Dornelas, Antigo, and Espertina, which are located further from the future open pits and processing ore facilities. A total of 72 cabbages, 24 soil samples, 24 irrigation water samples, and 10 drinking water samples from private and public supplies were collected from the selected farms. Three cabbage samples were harvested and analyzed for each farm as a pooled sample. The matching soil (<2mm fraction) and irrigation water samples were collected, together with drinking water. The ICP-MS was used to determine the concentration of As, Cd, Cu, Li, Ni, Pb, and Sn and ICP-OES for Ca, K, and Mg. Results were expressed as the average of three replicates and in fresh weight for cabbages. A socio-demographic questionnaire was applied to participants to collect information about demographic data, agricultural practices, and eating habits. Significant differences were observed only for Cd in the soils: levels in SA ranged between 0.1 and 0.26 mg $kg^{-1}$, compared to 0.07 and 0.16 mg $kg^{-1}$ in SB. Regarding Li, levels in both sites ranged between 21 and 35 mg $kg^{-1}$. All the irrigation water followed Portuguese regulations. Cd, Ni, Sn, K, Ca, and Mg levels were below the limit of quantification (LOQ) in irrigation water. The Li in both sites ranged between 1.1 and 15 µg $L^{-1}$. Regarding Pb and Cu, quantifiable results were observed at the SB, ranging from 0.69 to 12 µg $L^{-1}$ and 1.1 to 34 µg $L^{-1}$, respectively. For As, the samples from SA varied between 0.43 and 3.7 µg $L^{-1}$. All drinking water samples comply with the regulations except for Pb in one sample from site B (12 µg $L^{-1}$). All samples were below the LOQ for As, Cd, Sn, Tl, Mg, Ca, and K. In SB, the Pb varied between 0.7 and 12 µg $L^{-1}$. Li levels ranged between 1.1 and 5.9 µg $L^{-1}$ in both sites. In cabbage, Pb and Sn were below the LOQ. Significant differences were observed for Li between SA (96-589 µg $kg^{-1}$; median: 210 µg $kg^{-1}$) and SB (20-598 µg $kg^{-1}$; median: 86 µg $kg^{-1}$), as well as for As between SA (11-46 µg $kg^{-1}$; median: 20 µg $kg^{-1}$) and SB (4.5-31 µg $kg^{-1}$; median: 11 µg $kg^{-1}$). Li concentrations were lower than those reported in the literature (1200 µg $kg^{-1}$), while As median concentrations were in accordance with literature values (1-27 µg $kg^{-1}$). Based on cabbage and drinking water ingestion, the risk assessment revealed no current health concerns for the inhabitants. This exploratory study establishes an initial database for evaluating the potential future environmental and population impacts of mining activity.

**Keywords**: Lithium; Mining activity; Risk assessment; Food safety; Public health

# The use of organic amendments to mitigate Cu contamination in vineyard soils

Beatriz Fernandes[1,2], Cristiana Paiva[1,3], Diogo Machado[1,2], Verónica Nogueira[1,2], Anabela Cachada[1,3], Ruth Pereira[1,2]

[1]GreenUPorto/INOV4Agro, Campus de Vairão, Rua da Agrária 747, 4485 646 Vairão, Portugal;
[2]Departamento de Biologia da Faculdade de Ciências, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal
[3]Departamento de Geociências, Ambiente e Ordenamento do Território, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal

## Abstract (poster)

Copper (Cu) contamination in vineyard soils is currently a significant environmental concern due to the prolonged and intensive use of Cu-based fungicides, especially in organic viticulture, as no alternatives to these products are allowed to be used in this production mode. This continuous application led to an accumulation of Cu in soils, greatly impacting soil health as it negatively affects, among others, soil microbial activity, plant health and the overall ecosystem function. As these effects of Cu contamination depend on the physical and chemical properties of soils, which influence their vulnerability, prioritizing remediation efforts is essential. This remediation can be achieved by adding organic amendments to the soil, such as pine bark and mussel shells, two by-products of the forestry and fishing industries. This addition is expected to mitigate Cu contamination and add value to these industrial by-products. Considering this, different concentrations of a mixture of pine bark and mussel shell were incorporated into a Cu contaminated soil to verify if adding this mixture decreased its toxicity towards the non-target organisms of the ecosystem. The mixture of amendments was incorporated at 6, 12 and 26 g $kg^{-1}$ after soil incubation with Cu (0, 46, 72, 111, 173, 268, 416, 645 and 1000 g $kg^{-1}$) and stabilization for a month. The amended soils were kept under laboratory conditions for an additional month, after which physical and chemical soil properties were analysed and ecotoxicological assays with terrestrial (*Eisenia fetida* and *Medicago sativa*) and aquatic organisms (*Allivibrio fischeri* and *Lemna minor*) were performed, following standard protocols. The results showed that the mixture of these organic amendments effectively decreased Cu toxicity. Indeed, $EC_{50}$ values (concentration that produces a 50% effect) increased as much as 1.3 times for L. minor, 1.1 times for *E. fetida* and 2.8 times for *M. sativa* in the case of 12 g of amendment mixture, values that further increased when 24 g were added to the soil. Thus, this method offers a sustainable and eco-friendly solution for mitigating Cu contamination in vineyard soils, while ensuring the restoration of soil functionality and the sustainability of viticulture.

**Keywords**: Copper-based fungicides; Ecotoxicological assays; Remediation; Viticulture

# Hydrogeochemical assessment of coastal water resources in parts of Southwestern Nigeria

Oluwadamilola Fagade[1], Akinade Olatunji[1], Moshood Tijani[1], Jamiu Aladejana[1], Tibor Stigter[2], Remilekun Adeniyi[1]

[1]University of Ibadan, Ibadan, Oyo state, Nigeria.
[2]IHE Delft Institute for Water Education, Delft, Netherlands.

## Abstract (poster)

The coastal aquifers of Ilaje, Ondo State, southwestern Nigeria, located within the Eastern Dahomey Basin, face significant challenges from saltwater intrusion and contamination by potential waterborne disease pathogens, both of which exacerbate environmental degradation, public health risks, and socio-economic vulnerabilities. Evidence of saline water mixing has been established through various research; however a detailed assessment of the source and extent of groundwater salinization has not been undertaken. This research is therefore aimed at the investigation of the hydrogeochemical processes prevalent in aquifers in the part of the southwestern Nigeria coastline to gain better understanding of the effects of anthropogenic activities on the aquifers.

The field campaign for sample collection was done in two phases. Twelve Samples were collected from boreholes, hand-dug wells and a stream. Samples were collected during a preliminary sampling trip at Igbokoda and Ugbonla. These were analyzed for major ions using Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) and Ion Chromatography (IC). Physico-chemical parameters of further 84 groundwater samples collected during the dry season from wells (62) and boreholes (22) were also measured, and the samples were analyzed for bacteriological content using Nutrient agar (total heterotrophic count), MacConkey agar (coliform count) and Eosin Methylene Blue agar (Escherichia coli). Chemical analysis and interpretation were done with PHREEQC and CHEMDiagnostics.

Results revealed significant spatial variability in water quality, with electrical conductivity (EC) ranging from 21 µS $cm^{-1}$ to 26,600 µS $cm^{-1}$, indicating localized saline intrusion. While most samples fell within the acceptable pH range (6.5–9.5), elevated salinity (1860ppt) and TDS (1830 mg $L^{-1}$) levels in certain areas, such as Igbokoda, highlighted the impact of seawater intrusion. Heterotrophic bacteria were detected in 92% of the examined samples, with an average count of 82.4 cfu/100 ml. The average coliform count across 52% of the sites was 0.6 cfu/100 ml, with Ig7 recording the highest count at 81 cfu/100 ml. E. coli was detected in 8.3% of the locations, with a mean count of 3 cfu/100 ml. The faecal coliform counts across the study area were very low. This could be attributed to the lower water levels during the dry season when the samples were collected, as the lack of rainfall typically reduces water levels in the area. Geochemical plots, including Piper and Gibbs diagrams, identified dominant water types as Ca-Mg-$HCO_3$ and Na-Cl water types resulting from carbonate weathering, evaporation, and seawater mixing. The physicochemical parameters assessment indicated a considerable effect on drinking water quality due to their low to high contamination levels across the sample locations. Bacteriological analysis detected E. coli in 8% of samples, signalling faecal contamination, likely due to proximity to septic tanks and poor sanitation practices.

Future work will focus on wet-season sampling, spatial modelling of contamination risks, aquifer vulnerability mapping, and detailed isotopic analysis to further elucidate the hydrogeochemical dynamics governing groundwater systems in the study area.

**Keywords**: Coastal aquifers; Groundwater; Saltwater; Hydrogeochemical

# Sediment-water interaction and its impact on hydrogeochemistry in the Sajama National Park, volcanic zone of the Central Bolivian , Altiplano

Maria Isabel Chambi Tapia[1], Israel Quino Lima[2], Mauricio Rodolfo Ormachea Muñoz$_2$, Oswaldo Eduardo Ramos Ramos[2], Prosun Bhattacharya[1]

[1]KTH International Groundwater Arsenic Research Group, Department of Sustainable Development, Environmental Science and Engineering. Royal Institute of Technology, Stockholm, Sweden.
[2]Instituto de Investigaciones Químicas. Universidad Mayor de San Andrés. La Paz, Bolivia

## Abstract (oral)

A total of 59 samples were collected from various water sources (lakes, rivers, springs, thermal springs, wells) in the SNP. Field measurements include determinations of Temperature (T), pH, Ox-Red Potential (ORP), electrical conductivity (EC), total dissolved solids (TDS) and dissolved oxygen (DO). The Alkalinity, anions ($Cl^-$, $NO_3^-$, $SO_4^{2-}$), cations ($Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$), and (As, Li, B) were analyzed. Thirty sediment samples were digested using an $HCl/HNO_3$ acid. Secondary deposits of thermal origin were analyzed by ED-XRF. The samples showed temperatures (5.1 - 31.5) °C, pH (5.9 - 9.4). electrical conductivity (56 - 2330) µS $cm^{-1}$, and oxidation/reduction potential. Surface waters are predominantly of the Na-Cl-$HCO_3$ type, while groundwaters are mainly Na-Ca-Mg-$HCO_3$ type, and hot springs display a Na-Mg-$HCO_3$-Cl composition. Dissolved element concentration varied widely: As (0.004 -1900) µg $L^{-1}$, B (28 -11,792) µg $L^{-1}$, and Li (0.019 -2810) µg $L^{-1}$. Along the Sajama River, where the Milluri, Junthuma, Taipypuchuni, and Taypyjawira rivers converge, there is a significant accumulation of As, B, Li, and Fe. In river sediments, As (6.7 - 2006.6) mg $kg^{-1}$, B (21.1 - 419.2) mg $kg^{-1}$, Li (0.002 - 37) mg $kg^{-1}$, and Fe (13,997 - 369,997) mg $kg^{-1}$. Lagoon sediments show lower concentrations: As (14.7 - 19.8) mg $kg^{-1}$, B (27.2 - 33.5) mg $kg^{-1}$, Li (5.1 - 6.1) mg $kg^{-1}$, and Fe (11,759 - 29,353) mg $kg^{-1}$. Secondary thermal deposits contain As (18 - 73.6) mg $kg^{-1}$ and Fe (1,885 - 137,667) mg $kg^{-1}$. High enrichment and geo-accumulation of As and B in river sediments along the Sajama River are primarily attributed to geothermal sources, with additional contributions from sedimentary and volcanic rocks and decomposing organic matter. Li and Fe concentrations in river sediments show low to moderate enrichment, with the highest accumulation in the Junthuma River, also linked to geothermal sources. The hydrogeochemistry of the Sajama National Park system reflects a complex interplay of geothermal activity, sediment interactions, and geological processes. Variations in volcanic rock composition, ranging from dacitic to rhyolitic and ignimbritic, significantly influence water chemistry by affecting mineral solubility. Enrichment and accumulation of As and B in river sediments within the Sajama basin appear to result from continuous input from geothermal waters. The fine-grained sediments and deposited organic matter contribute to this accumulation, underscoring the dynamic geochemical environment of the region.

**Keywords**: Sajama National Park; Hydrogeochemistry; Sediment; Enrichment factor; Geo-accumulation Index

# Source apportionment of soil PTEs in a northern industrial county using PMF model: partitioning strategies and uncertainty analysis

Xiulan Yan[1]

[1]Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographic Sciences and Resources, Chinese Academy of Sciences

## Abstract (poster)

Positive matrix factorization (PMF) has commonly been applied for source apportionment of potentially toxic elements (PTEs) in agricultural soil, however, spatial heterogeneity of PTEs significantly undermines the accuracy and reliability of PMF results. In this study, a representative industrial-agricultural hub in North China (Xuanhua district, Zhangjiakou City) was selected as the research subject, multiple partition processing (PP) strategies and uncertainty analyses were integrated to advance the PMF modelling and associated algorithm mechanisms were comparatively discussed. Specifically, we adopted three methods to split the research area into several subzones according to industrial density (PP-1), population density (PP-2), and the ecological risk index (PP-3) respectively, to rectify the spatial bias phenomenon of PTE concentrations and to achieve a more interpretable result. Uncertainty analysis was taken into account by bootstrap (BS) and displacement (DISP) methods, showing that interval ratios of tracer species (Cd, Pb, Hg, and Zn) within the PP-3 were consistently lower compared to PP-1 and PP-2. Moreover, PP-3 PMF produces more consistent outcomes in all calculations. The PP-3 PMF results showed that natural sources, fertilizers and pesticides, atmosphere deposition, mining, and smelting were the primary sources, with contributions of 27.52%, 28.28%, 22.09%, and 22.11%. These four sources continue to be the primary sources according to other calculations, though the contribution from each source has varied. Compared to PMF results, the contribution of anthropogenic activities (fertilizers and pesticides, and atmospheric deposition) increased by 1.64% and 5.91% under PP-3 PMF. In contrast, the contribution of anthropogenic activities to PTEs was corrected by PP-3 PMF. Under the PP-3 PMF, the impact of the atmospheric source is heightened, leading to an expanded spatial distribution range. These findings demonstrate that partitioning processing can effectively improve the accuracy of PMF in agricultural soil with high heterogeneity of PTEs concentration, and quickly identify the main pollution areas to subsequently implement targeted control strategies.

**Keywords**: Source apportionment; Agricultural soil; PTEs; Spatial heterogeneity; Partitioning processing; Positive matrix factorization

# Assessment of potentially toxic elements (PTEs) in agricultural products from the Sepetiba Bay region, Brazil: implications for environmental and human health

Graziele Arantes Reis[1], Maria Virgínia Alves Martins[1,2], Lisia Maria Gobbo Santos[3], Carla Alexandra de Figueiredo Patinha[2], Fernando Rocha[2], Eduardo Ferreira Silva[2], Rubens César Lopes Figueira[4]

[1]Rio de Janeiro State University - Department of Geosciences, Rua São Francisco, 300, Rio de Janeiro, Brazil
[2]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal
[3]Oswaldo Cruz Foundation - Chemistry Department, Avenida Brasil, 4365, Manguinhos, Rio de Janeiro, 21040-900, Brazil
[4]University of São Paulo - Oceanographic Institute. Praça do Oceanográfico, 191 - CEP: 05508-120. Cidade Universitária, São Paulo (SP) - Brasil.

## Abstract (poster)

In contaminated regions potentially toxic elements (PTEs) can be transfer into the food chain through soil, water, and air. When introduced into the soil, PTEs are absorbed by plant roots and transported to aerial parts, increasing human exposure risks. The Sepetiba Bay region (RESB), a highly industrialized coastal area in Brazil, is significantly enriched with PTEs. This study evaluated PTE levels in agricultural products, including roots, fruits, leaves, seeds, cheese, and eggs, cultivated and marketed by local farmers in RESB. A total of 26 food samples sourced from organic markets were analyzed using ICP-MS. The results showed high concentrations of Zn > Cu > Ni > Cr > As > Pb > Co > Hg > Cd, with Zn, Cu, Cr, As, Pb, Hg, and Cd exceeding regulatory limits established by regulatory agencies. Cluster analysis (CA) and principal component analysis (PCA) grouped the PTEs according to their possible sources: As and Co (associated with metallurgical processes and the use of $As_2O_3$), Hg, Ni, and Cr (geogenic origin), and Pb, Zn, Cu, and Cd (strongly related to mineral processing activities). The Hazard Quotient (HQ) highlighted As and Cr as the most critical PTEs, and the Hazard Index (HI > 1) indicated a potential long-term carcinogenic risk for adults. These findings suggest that continued consumption of RESB-grown food may pose significant public health risks. This study provides a scientific basis for developing sustainable strategies to mitigate PTEs pollution and its impact on food safety and human health in RESB.

**Keywords**: Potentially toxic elements; Food contamination; Risk assessment; Environmental geochemistry; Medical geology

# Environmental exposure to heavy metals in a coastal industrial region of Rio de Janeiro (SE Brazil): biomonitoring and health risk assessment

Graziele Reis[1], Maria Virgínia Martins[1,2], Thaíse Machado Senez-Mello[1,3], Fernando Rocha[2], Carla Patinha[2], Eduardo Silva[2], Fernando Barbosa Junior[4]

[1]Rio de Janeiro State University - Department of Geosciences, Rua São Francisco, 300, Rio de Janeiro, Brazil
[2]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal
[3]University of São Paulo - School of Pharmacy, Av. Prof. Lineu Prestes, 580 - Butantã, São Paulo - SP, 05508-000, Brasil

## Abstract (poster)

Human tissues are important biological indicators for assessing the concentration of potentially toxic elements (PTEs) in populations residing in areas highly impacted by environmental contamination. This study aims to evaluate human exposure to chemical elements (Mg, Ag, Al, As, Ba, Be, Cd, Co, Cu, Zn, Se, Tl, Pb, Li, Rb, Sr, Mn, Ni, U, Sb, Cs, Sn, Hg) in the population living around Sepetiba Bay (SB), a coastal region in the state of Rio de Janeiro, Brazil. Partnerships were established with municipal agencies for project approval through the Instituto de Medicina Social Hésio Cordeiro (UERJ). Blood, hair, and nail samples were collected at Basic Health Units by specialized professionals and analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) to detect PTE concentrations. Statistical analyses were conducted to assess the associations between PTE levels and personal data, diet, health conditions, and medical histories obtained through questionnaires. Studies indicate that SB sediments present high pollution levels for Cd>Sn>Zn>Co>Pb>Ni>U>Mn>Sb>Hg>As. The highest detected PTE concentrations were found in blood: As (10.1 $\mu g.L^{-1}$), Al (2846.7 $\mu g.L^{-1}$), Ba (19.5 $\mu g.L^{-1}$), Li (2.7 $\mu g.L^{-1}$), Be (1.4 $\mu g.L^{-1}$), Co (1.3 $\mu g.L^{-1}$), Zn (9.9 $mg.L^{-1}$), Tl (0.6 $\mu g.L^{-1}$), Rb (8.8 $mg.L^{-1}$), Ni (3.7 $\mu g.L^{-1}$), U (3.6 $\mu g.L^{-1}$), Cs (9.2 $\mu g.L^{-1}$), Hg (10.2 $\mu g.L^{-1}$); hair: Ba (13.7 $\mu g.g^{-1}$), Cd (3.7 $\mu g.g^{-1}$), Co (1.2 $\mu g.g^{-1}$), Tl (21.1 $ng.g^{-1}$), Mn (4.2 $\mu g.g^{-1}$), Ni (30.3 $\mu g.g^{-1}$), Cs (21.2 $ng.g^{-1}$), Hg (2.8 $\mu g.g^{-1}$), Ag (171.5 ± 43.77 $\mu g.g^{-1}$), Sb (76.2 ± 115.00 $ng.g^{-1}$), Sn (16513.1 $ng.g^{-1}$); and nails: Al (232.4 $\mu g.g^{-1}$), Ba (57.0 $\mu g.g^{-1}$), Cd (3.5 ± 0.76 $\mu g.g^{-1}$), Co (4.3 $\mu g.g^{-1}$), Se (690.1 $ng.g^{-1}$), Tl (90.3 $ng.g^{-1}$), Pb (4.7 $\mu g.g^{-1}$), Sr (51.1 $\mu g.g^{-1}$), Mn (24.8 $\mu g.g^{-1}$), U (112.8 $ng.g^{-1}$), Hg (0.9 $\mu g.g^{-1}$), Ag (36.6 $\mu g.g^{-1}$), Sb (152.6 $ng.g^{-1}$) in the resident population around SB, with levels higher than reference values found in the literature. These findings reflect clear exposure of SB residents to the analyzed PTEs. Considerable discrepancies were observed in the accumulation of PTEs in different tissues, suggesting a bioaccumulation order: nails > hair > blood. This pattern can be explained by natural physiological factors such as elimination/growth rates, chemical element incorporation, exposure duration, and biological matrix. The differences in concentrations among bioindicators (blood, hair, nails) may suggest exposure classes associated with different timeframes: recent, medium-term, and chronic. The results offer insights into environmental exposure and human health risks, potentially contributing to developing and implementing public policies and environmental monitoring in industrially impacted coastal regions.

**Keywords**: Potentially toxic elements; Human exposure; Biomonitoring; Environmental geochemistry; Medical Geology

# Preliminary assessment of environmental contamination of the abandoned Pintor mine in the Portuguese Tin-Tungsten Metallogenic Province

Bárbara Fonseca[1], Carla Candeias[2], Fernando Rocha[2], Joaquim Góis[1], António Guerner Dias[3], Henrique Garcia Pereira[4]

[1]CERENA-FEUP (Centre for Natural Resources and Environment), Department of Civil Engineering and Georesources, Faculty of Engineering, University of Porto, 4200-465 Porto, Portugal
[2]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal
[3]Department of Geosciences, Environment and Spatial Planning, Faculty of Sciences, University of Porto, 4169-007 Porto, Portugal
[4]CERENA-IST (Centre for Natural Resources and Environment), Department of Civil Engineering, Architecture, Mining and Georesources, Instituto Superior Técnico, University of Lisbon, 1049-001 Lisbon, Portugal

**Abstract (oral)**

Neglect of abandoned mining areas has increasingly drawn the scientific community's attention due to the environmental impacts resulting from the closure of mining operations and the subsequent abandonment of processing facilities and mine waste deposits. This study investigates soil contamination in abandoned mining sites in the Portuguese Tin-Tungsten Metallogenic Province. Due to the large extent of the study area, a representative site selection was essential. A Binary Correspondence Analysis was employed, selecting six abandoned mines as case studies: Cerdeirinha, Regoufe, Ramalhoso, Pintor, Vale das Gatas, and Bejanca.

Sampling campaigns were conducted between April and November 2023. Approximately 30 soil samples were collected within the abandoned mining area for each site, using a grid as regular as terrain geomorphology allowed. Three background (control) samples were taken 4 km from each site to determine geochemical baseline levels. In total, 214 soil samples were collected, including 18 control samples. For this study, the Pintor mine was selected for detailed analysis, comprising 40 samples in total, including 3 control samples.

The samples were analyzed using X-ray Fluorescence (XRF) for chemical composition, X-ray Diffraction (XRD) for mineral phase identification, and a range of physico-chemical analyses (pH, electrical conductivity (EC), salinity, total dissolved solids (TDS), and organic matter (OM)) on the <250 µm fraction, obtained via wet sieving.

The chemical characterization revealed significant enrichment of potentially toxic elements (PTEs), including As, Cd, Cr, Mn, Mo, P, Sb, Sn, and W, in the soils from the former Pintor mining area. These elements' concentrations exceeded the regional geochemical background levels and international reference values for uncontaminated environments, indicating a substantial environmental risk associated with historical mining activities..

**Keywords**: Abandoned mining areas; Contamination; PTE; Geomathematics; Pintor mine

# Legacy of antimony and gold mining: potential ecological risks at Ribeiro da Serra Mine (Northern Portugal)

Patrícia Santos[1], Giulia Resta[1], Alexandre Lima[1], Deolinda Flores[1]

[1]ICT, Department of Geosciences, Environment and Spatial Planning, Faculty of Sciences of University of Porto, Rua do Campo Alegre s/n, Porto 4169-007, Portugal

## Abstract (oral)

The Valongo Anticline is well known for its gold and antimony mines, which were mostly explored until the beginning of the past century. Many of these mines are part of the region's legacy, and there are vestiges of this activity even today.

Ribeiro da Serra Mine, located 15km from Porto in the Gondomar Municipality, was one of the most significant Sb-Au mines in the Anticline and was active between 1858 and 1890. Nowadays, on-site remains significant waste piles, the largest of which measures 1.89 ha, along with the ruins of a washing plant, galleries, and shafts. All these structures were abandoned without any mitigation measures or interventions.

The study area is part of the Dúrico-Beirão Mining district, whose estimations indicate a production of approximately 1200 T of antimony and 2 T of gold from the Ribeiro da Serra and Tapada mines.

The Sb-Au mineralization occurs in quartz veins hosted in Beiras Group (Schist-Graywacke Complex -Lower Cambrian?), with the highest enrichment associated with N-S alignments dipping W.

In Ribeiro da Serra, different minerals, such as stibnite and berthierite, as well as their oxides and hydroxides alteration forms, pyrite, sulfosalts of antimony, silver, gold, and quartz, were identified. The mining wastes, accompanied by the processing residues deposited, are still enriched in various metals and metalloids.

To study the mine's ecological impact on the surrounding soils, 54 samples were selected both uphill and downhill of the mine. These were then prepared, dried at room temperature, sieved at 2mm, and crushed and sieved to less than 200 µm. Samples were digested by multi-acid, heated 0.25 g split in $HNO_3$, $HClO_4$, and HF to fuming, taken to dryness, and analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

The potential ecological risk index, established by Hakanson (1980), was applied to assess the mine's ecological impacts on the surrounding soils.

The geochemical analysis highlighted concentrations of potentially toxic elements as Sb, As, Pb and Hg that exceeded significantly the reference values for contaminated soils proposed by the Portuguese Environmental Agency – APA.

The ecological risk indexes of individual potential toxic elements (EI), indicate that the average EI value of each element decreased in the following order: Hg (57.7) > Cd (36.7) > Sb (22.0) > As (14.1) > Pb (7.16) > Cu (5.72) > Ni (5.56) > Cr (2.11) > Zn (1.09). The average EI values of Hg, considered medium risk, were significantly higher than those of other HMs. The Potential Ecological Risk Index calculated in the soils surrounding the Ribeiro da Serra mine indicates a medium risk, with 11% of samples presenting a medium ecological risk, 6% a considerable risk, and 8% of the samples presenting a high risk. The highest ecological risks are spatially distributed along the valley that drains along the mine waste piles.

**Keywords** Potentially toxic elements in soil; Antimony, Gold, Abandoned Mine

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# Assessment of the recency of organo-chlorine pesticides (OCPs) inputs in soil and their associated human health risk in the Sarno River basin (Southern Italy)

Annalise Guarino[1], Antonio Iannone[1], Alessio de Falco[1], Salvatore Dominech[1], Chengkai Qu[2], Stefano Albanese[1]

[1]University of Naples Federico II, Via Pansini 5, 80131 Naples, Campania, Italy
[2]China University of Geosciences, 388 Lumo Rd, Hong Shan Qu, Wu Han Shi, Hu Bei Sheng, China, 430079

**Abstract (oral)**

The catchment basin of the Sarno River (including its main tributaries, Solofrana and Cavaiola) in southern Italy has been historically recognized in the literature as one of the most contaminated in Europe.

Within its catchment, agricultural and industrial activities exert relevant pressure on the environment, sometimes posing risks to ecosystems and exposed humans.

Within the framework of the Return (Multi-Risk science for resilient communities under a changing climate) project funded by the EU through the NextGenerationEU initiative, a study was completed to assess the effect of historical agricultural practices on soil contamination. The concentration of 24 organo-chlorine pesticides (OCPs) (namely p,p'–DDT, o,p'–DDT, p,p'–DDD, o,p'–DDD, p,p'–DDE, o,p'–DDE, α–HCH, β–HCH, γ–HCH, δ–HCH, aldrin, dieldrin, endrin, endosulfan I (α–Endos), endosulfan II (β–Endos), endosulfan sulfate (ES), trans–chlordane (γ–Chlor), cis–chlordane (α–Chlor), heptachlor, trans–nonachlor, cis–nonachlor, HCB, mirex and methoxychlor) were assessed in 42 samples of agricultural soils.

Chemical data were evaluated by generating the spatial patterns of each compound.

The overall input recency of OCPs was assessed by generating a new index based on isomeric ratio analysis applied to four major OCP groups.

The health risk for local workers involved in agricultural practices was assessed considering dust inhalation as an exposure pathway; it represents, in fact, farmers' primary source of contact with contaminants stocked in soils. Risk analysis was conducted using both deterministic and stochastic approaches to assess cancerogenic and non-cancerogenic effects. Results of the deterministic assessment were used to generate risk maps for individual compounds and groups with common target organs (i.e, DDT, DDE, DDD).

Results showed that the applications of the different OCPs in the soil of the Sarno River catchment do not always share the same patterns, suggesting that local farmers use these substances for other purposes. In addition, the analysis of their application's potential recency highlighted how DDTs were recently used in some areas. However, their agricultural use has been banned in Italy since 1978, except for particular applications in floriculture and zootechnics.

Risk assessment based on dust inhalation showed that DDTs and their metabolites (DDD and DDE) pose a relevant risk to farmers, especially those in the river catchment's lower section (Alluvial plain).

**Keywords**: Pesticides; GIS mapping; Inputs recency; Risk assessment; Farmers

# Immobilization of multi-metal in contaminated soil from a smelting site by FeOB combined microbial induced carbonate precipitation

Chuan Wu[1], Yueru Chen[1], Shengguo Xue[1]

[1]School of Metallurgy and Environment, Central South University, Changsha 410083, China

## Abstract (oral)

Contaminated soils often contain a variety of heavy metal pollutants. However, due to the differences in the properties of heavy metal ions, the synergistic or antagonistic effects between them increase the difficulty of simultaneous removal. Biomineralization technology has the characteristics of low cost, high efficiency, and good adaptability to the soil environment, and has become a research hotspot of in-situ remediation technology. Studies have shown that microbial-induced carbonate precipitation has advantages in removing cationic heavy metals, such as lead and cadmium; however, there are few studies on arsenic. The iron minerals induced by iron-oxidizing bacteria can effectively reduce the availability of arsenic in the environment, and they can be complementary in the pollutant removal process. This study selected Sporosarcina pasteurii with high urease activity and Ochrobactrum EEELCW01 as the research objects to construct a composite bacterial system. The immobilization mechanism of simultaneous removal of Pb, Cd and As by biomineralization mediated by composite bacteria was studied, and the relationship between composite bacteria and nitrogen cycle was explored. The best materials were screened using an orthogonal test, and the column test was used to explore their remediation effect in the vertical direction and to explore their effect on the occurrence of heavy metals and soil community structure. Finally, the remediation effect was verified by a field test intended to provide strong data support for large-scale field remediation applications.

(1) The composite bacteria system was constructed. By comparing the results of single-metal systems and multi-metal systems, the metallogenic mechanism of simultaneous removal of lead, cadmium and arsenic by composite bacteria was explored. The composite bacteria could adsorb most Pb and Cd by -OH, C-O and C=O groups, but only 63% of As was removed. The mineralization precipitation can simultaneously remove more than 90% of heavy metals. After identifying ore-forming minerals, it was found that the ore-forming minerals of the composite bacteria were dense blocks of 10-15 μm, composed of calcite, goethite, magnetite, and amorphous crystals, clustered together. The minerals took the cell surface as the nucleation site and continued growing, connecting the cells. Heavy metals were wrapped or adsorbed on minerals, in which Pb was inside the mineral body, while Cd and As were mainly distributed on the surface of composite minerals.

(2) The orthogonal test determined the optimum material as 1% compound bacteria + 0.5M cementing fluid + zeolite'. The composite material reduced heavy metals' exchangeable state and carbonate binding state and transformed them into iron-manganese oxide binding state and residual state with higher stability. The toxicity leaching of Pb, Cd, As and Zn was reduced by more than 80%, which met the requirements of Class IV groundwater quality standard and remained stable within 60 days. The results of genomics showed that the composite material significantly increased the expression of nitrogen cycle genes such as nirK1, nosZ1, nosZ2, and ureC, indicating that the denitrification process of Ochrobactrum EEELCW01 was coupled with the synthesis of urease by Sporosarcina pasteurii, thereby promoting the formation of carbonate minerals.

(3) The effects of composite materials on the physical and chemical properties, heavy metal binding forms and microbial communities of contaminated soils at different depths were studied, and field test application verification was carried out. After the composite material was added to the soil, it had no significant effect on the soil pH and reduced the soil permeability through mineralization. The results of toxicity leaching showed that the remediation efficiency of composite materials for

heavy metals in different depths of soil was between 80% and 97%, and the leaching concentrations of Pb, Cd, As and Zn were less than 0.10 mg $L^{-1}$, 0.08 mg $L^{-1}$, 0.05 mg $L^{-1}$, and 0.45 mg $L^{-1}$, respectively. At the same time, the composite material has no significant effect on the microbial community structure of the soil. It can also promote the abundance of Enterobacter, Arthrobacter, Bacillus and other microorganisms in the soil. The field test results show that the composite material can reduce the effective content of heavy metals in the soil and make the toxic leaching concentration reach the groundwater quality class IV standard. In summary, the microbial composite material prepared in this study is an efficient, green, and economical remediation material with the prospect of being used in engineering applications.

**Keywords**: Heavy metal; Soil; FeOB; MICP

# The first Geochemical Atlas of mainland Portuguese Soils (*in memoriam* of Manuela Inácio)

Manuela Inácio[1], Virgínia Pereira[2], Orquídia Neves[1], Marina Cabral Pinto[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal.
[2]Centro de Recursos Naturais e Ambiente (CERENA), Departmento de Engenharia de Recursos Minerais e Energéticos (DER), Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1049-001 Lisboa, Portugal

**Abstract (Poster)**

Between 1994 and 2001, the Portugal mainland (89,000 km²) was covered by a low-density soil geochemical survey (652 samples: 1 site/135 km²) carried out by the Department of Geosciences of University of Aveiro (UA). The sampling and analytical protocols were implemented according to the recommendations of the IGCP Project 259 – International Geochemical Mapping (1988–1992) under the auspices of the United Nations Educational, Scientific and Cultural Organization – UNESCO's International Geological Correlation Programme (IGCP). Sampling sites near factories, heavy traffic roads, mines, and arable land were avoided. The samples that represent "natural" soils will allow for the estimation of geochemical data distribution and background or baseline concentrations in Portuguese soils.

Manuela Inácio (1964-2023), researcher of the GeoBioTec (UA), completed her PhD thesis, coordinated by Prof. Virgínia Pereira, in 2004, presenting in a 2nd volume the "Soil Geochemical Atlas of Continental Portugal", a tool for future multiple purposes. Until the last years of life, she worked and improved a Portuguese-English version to be published.

This Geochemical Atlas presents three spatial distribution maps for chemical elements (9 major and 23 minor), analysed by ICP-AES in aqua régia extracts (ACMELAB laboratory), corresponding to the following sets: (i) 652 samples (< 0.18 mm) of horizon A (topsoils); (ii) 195 samples (< 0.18 mm) of organic horizon; (iii) 165 samples (< 2.0 mm) of horizon A.

Different chemical elements are in alphabetical order, and at the end, essential parameters in the soil's characterization, such as pH, electrical conductivity and organic matter content, are presented.

The information for each element is organized into two parts. The first presents the statistical data relevant to the characterization of the national soils; a brief critical analysis is made of the analytical quality and spatial distribution maps for Portugal mainland and their regional variation models. The second presents data, resulting from bibliographic compilation, by chemical element: reference concentrations in soils, stream sediments and diverse lithologies; permissible concentrations in soils (international standards/legislation) and some indications on geochemistry, biological impact, effects on human health, etc.

Many interpretations can be made of the presented maps. However, the first geochemical database for mainland Portuguese soils, in memoriam of Manuela Inácio, will be available soon (e-book). This Atlas is a valuable resource for various scientific fields, including environment, agriculture, forestry, livestock, public and animal health, and the exploration and exploitation of mineral resources. It contributes decisively to national land use planning and supports global environmental policy.

**Keywords**: Soils; Geochemical Maps; Background/Baseline concentrations; Atlas; Land use planning; Portugal.

# Low-density geochemical study of soils from Maio Island (Cape Verde): Implications to human health

Rosana Neto[1], Diogo Medeiros[1], Luísa Diniz[1], Marina Cabral Pinto[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal

**Abstract (poster)**

Maio Island is considered one of the oldest of the Cape Verde, located in the south of this archipelago. The island is composed of both eruptive and sedimentary rocks. Geomorphological, a flat terrain predominates and the highest point, with an altitude of 427 meters, is the Monte Penoso. Despite the extremely arid climate, the island has a significant forested perimeter (≈ 3.500 hectares), which resulted from a reforestation plan. The population is mainly concentrated along the coast and depends mainly on fishing and agriculture. Although, the relevance of agriculture for populations, water scarcity and soil salinization have led to the progressive abandonment of several agricultural areas.

Volcanic regions are often associated with environmental hazards related with high concentrations of some potential toxic elements (PTEs) in soils, which can affect human health. The lack of previous geochemical studies on Maio Island was the main motivation for this work, by creating a geochemical database and assess the potential PTE enrichments, which can pose a risk to public health. To this end, 31 surface soil samples were collected in different areas of the island and taking in considerations the variability of the geological basement. The <63 µm fraction were analysed for mineralogy, physicochemical parameters, and chemical content. The three main exposure pathways (inhalation, ingestion, and dermal contact) were calculated with the carcinogenic and non-carcinogenic risk indexes.

The main mineral present in recent sedimentary units was quartz, whereas plagioclase and ferromagnesian silicates were prominent in volcanic units. The samples exhibit a circumneutral pH (between 7 and 8), and higher electrical conductivity (EC) values were determined in the sedimentary deposits. The geochemical results showed that Cr, Ni and Pb do not pose a carcinogenic risk to human health, but the same is not true for As, for which the carcinogenic risk values are surpassed for both children and adults.

**Keywords**: Metal(loid)s; Volcanic soils; Carcinogenic Human Health Risk Assessment; Risk mapping

MEDGEO 25 ISEG

# theme 4

## urban geochemistry, waste management and life quality

# Porous geopolymers as sustainable thermal insulation: incorporation of iron ore and foaming agent optimization

Andreia Santos[1], Slavka Andrejkovičová[1], Daniela Řimnáčová[2], Ivana Perná[3], Fernando Almeida[1], Fernando Rocha[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal.
[2]Department of Geochemistry, Institute of Rock Structure and Mechanics of the Czech Academy of Sciences
[3]Department of Material Structure and Properties, Institute of Rock Structure and Mechanics of the Czech Academy of Sciences

## Abstract (oral)

Thermal insulation is crucial in building design as it enhances energy efficiency and contributes to overall comfort. A solution is to use materials capable of minimising convective heat transfer through gas-filled micropores. The most significant percentage of heat is lost through walls, doors and windows. Presently, thermal insulation materials primarily consist of organic polymers, such as polystyrene foam and polyvinyl chloride foam, as well as fibrous materials like rock and glass wool. Although these insulation materials exhibit favorable thermal conductivity coefficients, their durability is limited, and their properties degrade over time. Furthermore, their production process is complex, requiring costly raw materials and high-temperature conditions, which result in substantial carbon emissions. As such, there is a pressing need for insulation solutions that possess low thermal conductivity and adequate mechanical strength, reduced energy consumption during production, and sustainability. One promising alternative is the use of porous geopolymers for thermal insulation. Geopolymers can withstand higher temperatures than organic insulating materials and have a thermal conductivity of less than 0.70 W/m·K, which is approximately 50% lower than materials based on ordinary Portland cement. This study investigated the incorporation of iron ore into porous geopolymers based on metakaolin. The formulations were developed by incorporating 0%, 10%, and 20% by weight of iron ore sourced from an iron mine in Moncorvo, Portugal. The research primarily addressed two key aspects: integrating iron ore into geopolymers and producing porous geopolymers using three different foaming agents: aluminum powder, hydrogen peroxide, and sodium perborate. To enhance sustainability, curing was conducted at room temperature. To evaluate the viability of the geopolymers, a series of procedures were employed, including X-ray diffraction, X-ray fluorescence, compressive strength, thermal conductivity, mercury porosimetry, and surface area analysis. In addition, the formulations with the best results were subjected to a durability test in an accelerated ageing chamber. Results have indicated that geopolymers containing hydrogen peroxide and sodium perborate exhibited porosity values ranging between 47% and 55%, whereas those incorporating aluminum powder had 35% and 39% porosity values. Nevertheless, the higher the porosity, the lower the compressive strength. The foaming agent with the highest compressive strength was aluminum powder, achieving approximately 13 MPa with 20 wt.% iron ore after 90 days of curing. However, this formulation exhibited a thermal conductivity of 0.391 W/m·K, three times higher than the formulation using sodium perborate with 100% metakaolin, which had a thermal conductivity of 0.110 W/m·K. On the other hand, the sodium perborate formulation did not achieve a compressive strength exceeding 1.5 MPa. Due to the high compressive strength values, the geopolymers with aluminum powder were subjected to a durability test. After 30 summer/winter cycles, the compressive strength test was carried out again, and only a 12% decrease was observed. Based on a comprehensive analysis of the results, geopolymers have demonstrated favorable properties that make them a viable alternative to conventional insulating building materials.

**Keywords**: Geopolymers; Thermal insulation; Chemical foaming; Thermal properties; Sustainability

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# Effects of simulated acid rain and freeze-thaw cycles on compressive strength and heavy metal curing of geopolymer mortar

Jia Li[1], Hengpeng Ye[1]

[1]South-Central Minzu University, and its address is No. 182, Minzu Avenue, Wuhan City, Hubei Province

## Abstract (poster)

Geopolymer, a new type of green inorganic cementitious material, is regarded as an ideal substitute for cement. In this study, a new ternary geopolymer (GPP) was prepared using electrolytic manganese slag(EMR), phosphogypsum(PG) and blast furnace slag(GGBS) as components and PVA fibers were added to improve the overall performance of the mortar. These materials were selected because a) EMR, as the primary by-product of the production process in the electrolytic manganese metal sector, contains a significant quantity of $SiO_2$ and gypsum and is a good source for Si and Ca; b) PG, as an industrial waste produced during the production of wet process phosphoric acid, often is released in vast amounts but is underutilized, resulting in a significant loss of land assets and severe environmental pollution if not being treated immediately; and c) GGBS has good hydration properties and is widely used in the cement and concrete industry.

Acid rain corrosion and freeze-thaw cycles significantly reduce the cracking resistance of geopolymer mortar pavements and accelerate the deterioration process of geopolymer mortar, which not only shortens the service life of pavements but also may lead to serious safety risks. To explore the changes in compressive and flexural strength of geopolymer mortar mixed with PVA fibers(GPP) and geopolymer mortar mixed with PVA fibers and basalt fibers (GPPB), as well as heavy metal ion leaching, mass loss, and strength degradation, characterization methods such as XRD, SEM, and BET were used to study the microstructural damage evolution of the mortar during acid rain immersion and freeze-thaw cycles. The results showed that the mixed-fiber geopolymer mortar GPPB has better acid corrosion and freeze-thaw resistance than single-fiber geopolymer mortar GPP. Accurate characterization of the microstructural evolution of ground polymer mortar will help to reveal the damage mechanism behind the deterioration of macro-mechanical behaviour of the geopolymer mortar in the environments of acid-rain corrosion and freezing/thawing cycles.

**Keywords**: Industrial solid waste; Geopolymer mortar; Fiber; Compressive and folding strength

# Wildfire prevention: the economic potential of biochar-based business models

Ana Morim[1], Mara Madaleno[2], Luís Tarelho[1], Flávio Silva[1]

[1]Department of Environment and Planning, University of Aveiro; Centre for Environmental and Marine Studies (CESAM)
[2]Department of Economics, Management, Industrial Engineering and Tourism, University of Aveiro; Research Unit in Governance, Competitiveness and Public Policies (GOVCOPP)

## Abstract (poster)

Portugal suffers from recurrent wildfires that degrade all environmental compartments. These fires substantially affect human health due to their immediate impact on air quality, primarily through particulate matter, NOx, and COx emissions. This can lead to severe health impacts, such as the exacerbation of respiratory diseases. Forest maintenance is an effective strategy for wildfire prevention, as forests cover 36% of Portugal's land area. This maintenance consists of residual forestry biomass removal, which acts as a fire propagation vector, and its conversion into an added-value product, such as biochar. Biochar is a carbonaceous material made from the thermochemical conversion of biomass at relatively low temperatures (300 – 700 °C) in an oxygen-free atmosphere. Its properties make it an ideal material for various applications (e.g., adsorbent, soil additive, catalyst) while also functioning as a carbon sink due to its recalcitrant nature. Pyrolysis for biochar production can be a viable alternative to combustion or gasification, which often causes equipment slagging and ash production depending on the biomass used. Business models were developed and evaluated to promote the removal of residual forestry biomass and its conversion into biochar, thus encouraging forest maintenance operations to stimulate rural economies. To our knowledge, no residual biomass business models have been studied. Therefore, several scenarios for decentralized pyrolysis for biochar production were tested and classified under the economic activity code of "Forest Exploration". The key difference between each model lies in how much the production process is integrated into revenue streams: (a) Model 1- Biochar with associated carbon credits commercialization; (b) Model 2- Forest maintenance operations and biochar with associated carbon credits commercialization; and (c) Model 3- Forest maintenance operations, biochar with associated carbon credits commercialization, and sale of the biomass surplus.

The following assumptions were made: (a) A project lifetime of 20 years; (b) Pyrolysis is conducted in a continuous autothermal reactor with a processing capacity of 250 kg dry biomass/h; (c) Pyrolysis efficiency of 20%; (d) Reactor maintenance fees of 2.5% of its commercial price; (e) Rotative drum biomass dryer powered by the surplus energy produced by the combustion of pyrolysis gases, and (f) Weighted Average Cost of Capital (WACC) of 3.59%, based on data from the Bank of Portugal's Sector Tables. To evaluate each business model's financial feasibility, the Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP) were calculated. Model 1 had a negative NPV, which indicated that the costs surpassed the gains throughout the project's lifetime. Models 2 and 3 were financially viable with a NPV of 893 316.71 € and 1 746 508.79 €, respectively. However, Model 3 had the highest IRR of 23% compared to the 15% of Model 2 and the lowest PP of 5 years. Model 3 presents the best financial and environmental benefits with the potential for engaging stakeholders in sustainable forest management. Therefore, a forest-related business must integrate the production process to be profitable while promoting wildfire prevention and forest maintenance.

**Keywords**: Wildfires; Techno-economic analysis; Biochar; Fire prevention;

# Urban sediments geochemistry and associated environmental health risk of a small urban area from NE Portugal

Anabela Ribeiro dos Reis[1,2], Rui José Santos Teixeira[1,2]

[1]Department of Geology, School of Life and Environmental Sciences, UTAD - University of Trás-os-Montes e Alto Douro, Quinta de Prados, 5000-801 Vila Real, Portugal
[2]CGeo - Geosciences Center of the University of Coimbra, University of Trás-os-Montes e Alto Douro Pole

## Abstract (poster)

The population of urban areas is exposed to increasingly large amounts of contaminants, mainly associated with road-deposited sediments (RDS). Contaminants in RDS, including fine particulates, are susceptible to remobilisation to the local atmosphere or can be transported by runoff to the surrounding river drainage system. Therefore, the increase in population in urban settlements requires health risk assessment and effective management of urban sediments, and research on this subject is needed. This study aimed to evaluate the contents and its spatial distribution of trace metals in dust particles from the town of Vila Real, NE Portugal, considering the underlying geochemical associations and mineralogical composition of dust particles.

Samples of RDS were collected from urban, periurban and industrial areas, as well as public playgrounds. The < 1000 and < 63 μm sediment fractions were separated and subjected to chemical analysis. The potential mobility of As, Cd, Co, Cr, Cu, Ni, Pb, V and Zn was assessed using a modified BCR sequential extraction procedure, and the residual fraction was decomposed with aqua regia. Copper, Pb and Zn associations were observed in samples collected in streets with high traffic density and industrial activity. In contrast, associations between V, Cr, and Ni were found in samples collected near garden areas and in green parks. High concentrations of Cu, Ni and Zn were associated with the exchangeable/carbonate phase, in streets subject to higher vehicular traffic, and therefore the most labile metals. Lead, Zn, and to a lesser extent Cu showed relatively high proportions associated with the reducible fraction. In contrast, Cu, Cd and V showed relatively high proportions related to the oxidisable fraction. These observations suggest that these metals can be considered relatively immobile in street dust sediments, subject to mobilisation if changes in pH or redox occur during transport by runoff or after deposition in surface water bodies. The contents of As, Zn, and V were higher in the fraction <63 μm; Cr and Cu were higher in the coarser fraction, in samples collected in streets with higher traffic; Ni and Pb were higher in the fraction <1000 μm. The results suggest that particles detached by the corrosion or abrasion of vehicle and building parts are the main sources of metals, yielding coarser particles into the urban environment. The selected RDS samples analysed under scanning electron microscopy (SEM-EDS) in polished grain mounts indicate the presence of Al-Si alloys with Fe, nodular cast iron, rust-derived dust from the oxidation of metal surfaces, rubber particles derived from automobile tires and cement/concrete particles. Many of the materials identified in urban sediments are small enough to be suspended in the air and may affect human health, primarily through inhalation and/or ingestion. The impact of urban runoff waters on aquatic ecosystems is also a concern.

**Keywords**: Urban sediments, Metalloids; Sequential extraction; Electronic microscopy, Pollution

MEDGEO 25 ISEG

# theme 5

## toxicological and epidemiological pathways on human health

# Perfluorooctane sulfonate causes damage to human umbilical vein endothelial cells through oxidative stress and ferroptosis

Jiajing Cui1, Shuqi Yan1, Yiyu Xu1, Xiaomei Liu1, Lei Shi1, Chunping Lv1, Shuping Ren1

[1]Department of Occupational and Environmental Heath, School of Public Health of Jilin University. NO.2699 Qianjin Street,Changchun,Jilin,P.R.China

**Abstract (Poster)**

Perfluorooctane sulfonic acid (PFOS) is an anthropogenic chemical containing fluorinated surfactant, one of the Per- and polyfluoroalkyl substances (PFAs). PFOS is receiving increasing attention because it is extremely resistant to degradation, bioaccumulates in food chains, and has long half-life in humans. Epidemiological research indicates that exposure to PFAs could increase the risk of developing cardiovascular diseases. However, the exact mechanisms underlying endothelial cells injury caused by PFOS remain unclear. Human Umbilical Vein Endothelial Cells (HUVECs) were treated with PFOS or Fer-1. The levels of ROS, ferroptosis related parameters, cell migration, endothelium damage related parameters and endothelium-derived diastolic mediators were measured to determine whether oxidative stress and ferroptosis are involved in the damage of endothelial cells by PFOS. The results showed that PFOS could increase the levels of ROS, the content of Fe2+ and MDA; decrease the content of GSH and GPX4 in HUVECs; PFOS could inhibit the migration of HUVECs. Based on the findings, the present study concluded that PFOS could trigger ferroptosis of HUVECs through inhibiting SLC7A11-GSH-GPX4 and cause HUVECs damage by activating oxidative stress and ferroptosis pathway.

**Keywords**: Perfluorooctane sulfonate; Oxidative Stress; Ferroptosis; Human Umbilical Vein Endothelial Cells

# Mitophagy dynamics mediating oxidative to reductive stress shift for potentiating arsenite-induced malignant transformation potential in human keratinocyte

Xiaoyan Zhong[1], Qianlei Yang[1], Qi Kong1, Yan An[1]

[1]Soochow University

## Abstract (oral)

Carcinogenicity from arsenic exposure is a global public health challenge. Unlike the well-researched oxidative stress hypothesis of carcinogenicity, reductive stress as a mechanism of carcinogenesis has been described only recently, and the mechanism by which cancer cells survive the transition from oxidative to reductive stress remains unclear. In this study, arsenite-induced malignant transformed human keratinocytes (T-HaCaT) are established as a research model to mimic long-term, low-dose exposure, investigating the role of mitophagy dynamics during the shift from oxidative to reductive stress conditions. In non-transformed HaCaT, sodium arsenite (NaAsO2) exposure induces oxidative stress at both cellular and mitochondrial levels at the early stage, while changing to reductive stress at the late stages during malignant transformation. The redox shift from oxidative to reductive stress is attributed to a sustainably expressed nuclear factor erythroid-2 related factor 2 (NRF2), increasing mitophagy that is dependent on PTEN-induced putative kinase 1 (PINK1)-PARK2 encoded E3 ubiquitin ligase (Parkin) pathway. When mitophagy is inhibited by cyclosporin A (CsA) or NRF2 siRNA transfection, the expressions of PINK1 and Parkin, as well as the number of mitolysosomes are significantly decreased. Conversely, when cells are exposed to the mitophagy agonist carbonyl cyanide 3-chlorophenylhydrazone (CCCP), their increased expressions result in elevated cell migration rates, soft agar clones, and shortened cell doubling times, all consistent with malignant transformation. The results indicate that chronic exposure to arsenite shifts the intracellular redox potential from oxidative to reductive stress, promoting the malignant transformation potential of HaCaT via NRF2-activated, PINK1/Parkin pathway-mediated increased mitophagy. These findings may provide a new research perspective for exploring molecular mechanisms underlying arsenic-induced malignant transformation, oncogenesis, and its control in exposed populations.

**Keywords**: Arsenite exposure; Redox shift; Mitophagy dynamics; Mitochondrial redox; Spatio-temporal precision regulation

# Associations of residential green space with motor, language, and cognitive development in children: a nationwide study in China

Ruili Li[1], Zitong Chen[2], Bowen Chen[3], Qingli Zhang[4], Xiaoning Lei[2]

[1]Department of Children Health and Development, Capital Institute of Pediatrics, Beijing, China
[2]School of Public Health, Shanghai Jiao Tong University School of Medicine, Shanghai, China
[3]Department of Children Health and Development, Capital Institute of Pediatrics, Beijing, China
[4]Ministry of Education - Shanghai Key Laboratory of Children's Environmental Health, Xinhua Hospital Affiliated to Shanghai Jiao Tong University School of Medicine, Shanghai, China

## Abstract (oral)

Objectives: Green space may promote child neurodevelopment across multiple domains and stages of development. This study investigated associations between residential green space exposure and motor, language, and cognitive development in children aged 1–6 years.

Methods: We included 8,571 children from a nationwide survey in China. Child developmental quotient (DQ) was assessed using the Children's Developmental Scale of China, covering five domains: gross motor, fine motor, language, adaptability, and social behavior. Residential greenness was estimated using the Normalized Difference Vegetation Index within 1000-meter buffer (NDVI1000m). The six exposure windows included the preconception period (12 weeks before pregnancy), the prenatal periods (first [T1], second [T2], and third [T3] trimesters, and the entire pregnancy), and the postpartum period (one year before outcome assessment). Multivariable linear regression models were employed to examine the associations of NDVI1000m and child DQ.

Results: Associations between greenness and child DQ varied by domain and exposure window. Every 0.2-unit increase in NDVI1000m during all six exposure windows was consistently associated with higher DQ in gross motor (β T3 = 1.51, 95% CI: 0.90, 2.12 ~ β postpartum = 2.60, 95% CI: 1.83, 3.37) and fine motor (β T3 = 2.00, 95% CI: 1.41, 2.58 ~ β postpartum = 2.50, 95% CI: 1.84, 3.17) domains. Conversely, higher NDVI1000m during preconception and prenatal periods was associated with lower language DQ (β T2 = -0.72, 95% CI: -1.37, -0.06 ~ β entire pregnancy = -1.09, 95% CI: -1.84, -0.35). No associations were observed for adaptability or social behavior.

Conclusions: Our findings suggest that residential green space may promote motor development but may have an adverse effect on language development in young children. These results highlight the importance of considering domain-specific effects of green space exposure in early life.

**Keywords**: Green space; Child neurodevelopment; Early life exposure; Motor development; Language development

# Separate and combined associations of PM2.5 exposure and smoking with dementia and cognitive impairment

Xi Chen[1], Kangfeng Zhao[1], Liying Fu[2], Jianjia Li[2]

[1]National Institute of Environmental Health, Chinese Center for Disease Control and Prevention
[2]Beijing University of Technology

## Abstract (oral)

Objective: Studies of the relationship between environmental pollution and dementia are limited and controversial. Here, we analysed the combined effects of PMv and smoking on the prevalence of dementia and cognitive impairment in a community-dwelling Chinese elderly population.

Methods: A total of 24,117 elderly people were assessed using annual average PMv concentrations from 2012 to 2016. Dementia in the baseline survey was subject to confirmation by a qualified clinical facility, and newly suspected dementia was assessed in 2017 after excluding suspected dementia in 2015. National census data were used to weight the sample data to reflect the whole population of China, and multiple logistic regression was performed to analyse the combined effects of variable PMv and smoking levels on dementia and cognitive impairment.

Results: Individuals exposure to the highest PMv concentration and daily smoking had a higher risk of dementia than those in the lowest PMv concentration group (OR, 1.603, 95%CI [1.626-1.635], P<0.0001) and the non-smoking group (OR, 1.248, 95%CI [1.244-1.252], P<0.0001). Moderate PMv exposure and occasional smoking together enhanced the risk of cognitive impairment in the short term. High-level PMv exposure and smoking are associated with increased dementia risk, and greater efforts are needed to reduce the risk of dementia through environmental protection and anti-smoking campaigns.

Conclusions: High-level $PM_{2.5}$ exposure and smoking are associated with increased dementia risk. Lower ambient $PM_{2.5}$ concentration and smoking cessation are recommended to promote health.

**Keywords**: $PM_{2.5}$ exposure; Smoking; Dementia; Cognitive impairment; Environmental protection; Smoking cessation

# Residential greenspace and blood lipid profile: a nationwide longitudinal study

Yicong Wang[1], Zhaoyang Pan[1], Xueyan Han[1], Jian Guo[1], Yuanli Liu[1], Teng Wang[1], Tianjia Guan[1]

[1]School of Health Policy and Management, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China, 100730

**Abstract (oral)**

Background: Current evidence for residential greenspace and blood lipid levels primarily based on single-center cross-sectional studies, with spatial and temporal differences possibly leading to heterogeneous results. This large multicenter community-based study aimed to investigate the longitudinal relationships between residential greenspace and blood lipids.

Methods: We included participants over 40 years with repeated blood lipid measurements from the China National Stroke Screening Survey (CNSSS) from 2013–2019. Greenspace exposure was assessed using the three-month average normalized difference vegetation index (NDVI) with a spatial resolution of 1 km. Linear fixed-effect models examined the associations between greenspace and low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides (TG), and total cholesterol (TCHO) levels, adjusting for demographic characteristics, lifestyle factors, and a history of chronic diseases. Air pollution and physical activity were considered as potential mediators.

Results and conclusion: We included 292,754 participants with 683,759 visits. A 0.1-unit increase in NDVI was significantly associated with a 1.28% increase in HDL-C (95% confidence interval [CI]: 1.06%, 1.51%), and decreases of 0.63% in LDL-C (95% CI: 0.88%, 0.38%), and 1.45% in TCHO (95% CI: 1.64%, 1.26%). These associations were modified by sex, history of dyslipidemia, hypertension, smoking and drinking. We observed a nonlinear exposure-response curve (ERC) for the association between greenspace and lipid indicators. Air pollution ($PM_{2.5}$, $NO_2$) partially mediated the associations between residential NDVI and LDL-C, HDL-C, and TCHO. In conclusion, this longitudinal study found that greater residential greenspace was associated with improved blood lipid levels. Air pollution is a significant mediator linking green environments to blood lipids.

**Keywords**: Greenspace exposure; Blood lipids; Longitudinal study; Mediation

# Arsenic Exposure in Drinking Water and Occurrence of Chronic Kidney Disease: The Association and Effect Modifications by Comorbidities

Shih-Chieh Huang[1], Ya-Yun Cheng[1,2], Yen-Cheng Tseng[3], How-Ran Guo[1,4]

[1]National Cheng Kung University
[2]National Sun Yat Sen University
[3]Chang Jung Christian University
[4]National Cheng Kung University Hospital

## Abstract (poster)

Background: In the early 1910s and late 1940s, residents of areas in southwestern and northeastern Taiwan were subject to long-term arsenic exposure through high-arsenic artesian well water. Although these endemic areas currently utilize public water supply systems using surface water, many area residents may still suffer from chronic health effects caused by arsenic exposure from drinking water, such as cancers of the skin, urinary bladder, and kidney, hypertension, diabetes mellitus, and renal injury (specifically glomerular and tubular interstitial damage), which may progress to Chronic Kidney Disease (CKD). Therefore, we conducted this nationwide population–based study in Taiwan, where the prevalence of chronic kidney disease (CKD) is high, to assess the potential association between arsenic exposure in drinking water and CKD, as well as the effect modifications by comorbidities.

Methods: We conducted a retrospective cohort study in Taiwan, focusing on the island and its southwestern region specifically. Our cohorts comprised members aged 40 or older on January 1, 1998. Using the National Health Insurance Database, we identified patients of CKD newly diagnosed between January 1, 1998 and December 31, 2014. Arsenic levels in drinking water were assessed according to a nationwide census survey for 311 townships conducted by the government from 1974 to 1976. Hazard Ratios (HRs) contrasting CKD risk between arsenic exposure levels were estimated using Cox proportional hazard regressions and concurrently adjusted for potential confounders' effects. We also employed the Kaplan-Meier curve and Log–Rank test statistics to evaluate the differences in the cumulative probability of not being diagnosed with CKD between the two arsenic exposure groups. Lastly, we performed stratified analyses to assess the effect modification of comorbidities.

Results: In the study cohort of 6,573,192 participants in the whole region of Taiwan, we identified 1,203,088 patients newly diagnosed with CKD during the study period and found that residents of areas with arsenic levels ≥ 0.05 mg $L^{-1}$ in the drinking water had a HR of 1.185 (95% confidence interval [CI]: 1.180–1.189) for CKD. After adjusting for age, sex, income, urbanization level and related comorbidities, we found an adjusted HR of 1.153 (95% CI: 1.148-1.157), which was still statistically significant. Furthermore, we found that the effect was modified by comorbidities, with more pronounced effects in patients with more than three comorbidities (adjusted HR [AHR] = 1.178; 95% CI: 1.171–1.185). In southwestern Taiwan, we also observed a significant association between arsenic exposure and CKD (AHR=1.028, 95% CI: 1.021–1.035). The effect modified by comorbidities was more evident on patients with one or two comorbidities (AHR=1.079; 95% CI: 1.068–1.090).

Conclusions: Excessive exposure to arsenic in drinking water may increase the risk of developing CKD. Prevention and control of high-risk comorbidities in residents of arseniasis–endemic areas are crucial for reducing the risk of developing Chronic Kidney Disease (CKD).

**Keywords**: Arsenic: Drinking Water; Chronic Kidney Disease; National Health Insurance; Taiwan

# Short-term exposure of non-optimal temperature and lung function: The role of relative humidity

Tianjia Guan[1], Hailu Zhu[1], Yicong Wang[1], Xueyan Han[1], Ke Huang[2], Ting Yang[2], Chen Wang[3]

[1]School of Health Policy and Management, Chinese Academy of Medical Sciences and Peking Union Medical College
[2]National Center for Respiratory Diseases; State Key Laboratory of Respiratory Health and Multimorbidity; National Clinical Research Center for Respiratory Diseases; Institute of Respiratory Medicine, Chinese Academy of Medical Sciences; Department of Pulm
[3]Chinese Academy of Medical Sciences and Peking Union Medical College

**Abstract (oral)**

Rationale: Previous studies on ambient temperature and large airway function remain sparse and inconsistent, and none have specifically addressed the effects of ambient temperature on small airways. Specifically, the modifying role of relative humidity in temperature-related lung function impairment remains underexplored despite experimental evidence of synergistic biological interactions.

Objectives: To investigate the effects of ambient temperature on both large and small airway function and the interactive effects of relative humidity on lung function.

Methods: Pulmonary function results were obtained from a national cross-sectional study, the China Pulmonary Health Study (N = 42805). Multivariable linear models and generalized additive models were used to examine the associations between temperature and lung function. We investigated the interactive effects of non-optimal temperatures and relative humidity on lung function.

Results: All lung function consistently exhibited J-shaped exposure-response relationships. Low and high temperatures were significantly associated with decreased lung function compared to moderate temperatures. Participants exposed to both low temperature and low relative humidity had more pronounced reductions in FEV1 (-90.34 ml; 95% confidence interval [CI]: -113.35, -68.52), FVC (-93.23 ml; 95%CI: -118.72, -67.73), FEF25-75 (-165.56 ml; 95%CI: -204.98, -126.14) and other lung functions than did those in the moderate temperature and high relative humidity group.

Conclusion: Significant associations were observed between non-optimal temperatures and decreased lung function, with more pronounced reductions under low temperatures and low relative humidity, especially in small airway lung function. Urgent action is needed to mitigate the negative effects of temperature and moisture on lung function through increasing awareness and implementing adaptive strategies.

**Keywords**: Ambient temperature; Relative humidity; Interactive effect; Cross-sectional study; Lung function

# New dimensions in zeolite adsorption research on combating mercury toxicity in humans

Theophilus Davies[1], Alfred Msomi[1], Wilfred Dathe[2]

[1]aculty of Applied and Health Sciences, Mangosuthu University of Technology, KwaZulu Natal Province, South Africa
[2]Heck Bio-Pharma GmbH, Gerberstraße 15, 73650 Winterbach, Germany.

**Abstract (oral)**

Given its well-established impacts on human health, inherent toxicity, and tendency to accumulate in living organisms, mercury pollution is of grave concern to humanity. Notably known toxicity of this non-essential element includes neurological and carcinogenic effects. Therefore, the elimination of mercury in humans is of prime importance.

During the last century, various techniques have been employed to remove mercury ions from different contaminated environmental media. Still, recent research has shown adsorption to be one of the most competitive and efficient methods, particularly when utilizing suitable adsorbents. Among various materials used in adsorption trials, zeolite is a promising, economical, and environmentally friendly material. For the clean-up of toxic metals (TMs) such as mercury, natural and engineered zeolites are also one of the most well-established adsorption technologies. The attractiveness of zeolite as an absorbent for TMs is bolstered by its well-defined micropore dimensions and a composition within a strict crystal lattice.

The overarching objective of our research is to contribute towards parametric optimization of zeolites from South Africa and Germany, respectively, to obtain the highest possible efficiency in modulating mercury toxicity through adsorption processes by in vitro applications in humans. We aim to determine the binding affinity between mercury and zeolite in detail, exploring the possibilities of achieving optimal mercury elimination through various modifications of the zeolites in medical applications.

**Keywords**: Zeolite; Mercury; Adsorption; Pharmaceutical Applications

# A food safety perspective on iron, zinc, copper and nickel levels in Mytilus galloprovincialis collected along the Portuguese coast

Susana Coelho[1,2], Pedro Pato[3], Carla Patinha[3], Susana Galante-Oliveira[2] , Carlos Barroso[2], M. Ramiro Pastorinho[4], Ana Catarina Sousa[1]

[1]Universidade de Évora, Comprehensive Health Research Centre (CHRC), Escola de Ciências e Tecnologia, Évora, Portugal
[2]Centro de Estudos do Ambiente e do Mar (CESAM) e Departamento de biologia, Universidade de Aveiro, Aveiro, Portugal
[3]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal
[4]Universidade de Évora, Comprehensive Health Research Centre (CHRC), Escola de Saúde e Desenvolvimento Humano, Évora, Portugal

## Abstract (poster)

Objective: The blue mussel, Mytilus galloprovincialis, is highly consumed in Portugal and therefore it is important to assess the levels of contaminants to guarantee food safety. In this study, we evaluated the levels of the essential metals Nickel (Ni), Copper (Cu), Iron (Fe) and Zinc (Zn) in mussels' tissues.

Methods: Mussels were collected by hand at 44 locations along the Portuguese coast. In the lab, mussels´ soft tissues were removed, homogenized, freeze-dried, and reduced to powder. The tissues (250 mg) were then digested using nitric acid before inductively-coupled plasma mass spectrometry (ICP-MS) analysis. Quantification was performed with random duplicates, and the percentage recovery of the reference material (ERMCE278K) was 87, 99, 90 and 100 for Ni, Cu, Fe and Zn, respectively.

Results: The metals' concentration pattern varied considerably along the coast. The highest levels of Ni were recorded at the Zambujeira - Cabo Sardão and the lowest in Viana do Castelo shipyard (North) (0.9 and 0.1 $mg.kg^{-1}$ Wet Weight (WW), respectively). For Cu, the highest levels were recorded in the Sines fishing port, and the lowest were recorded at Praia do Guincho, Lisbon (11 and 0.6 mg kg-1 WW, respectively). The highest levels of Fe were registered in Belém Marina (Lisbon) and the lowest at Figueira da Foz fishing port (120 and 19 $mg.kg^{-1}$ WW, respectively). For Zn, the highest concentrations were recorded in Zambujeira - Cabo Sardão, and the lowest in Figueira da Foz Marina (130 and 21 mg kg-1 WW, respectively).

According to the European Food Safety Authority (EFSA) the Tolerable Daily Intake (TDI) for Ni is 0.013, mg.kg-1 body weight, which limits the consumption of an adult, 70 kg individual, to 970 g $day^{-1}$ of mussels collected at the highest contaminated location. Considering the Acceptable Daily Intake (ADI) set by EFSA (0.07 $mg.kg^{-1}$) for Cu, the same individual can eat up to 460 g $day^{-1}$ of mussels from the highest contaminated location. Regarding Fe and Zn, an adult's Tolerable Upper Intake Level (TUIL) is 40 and 25 mg $day^{-1}$, respectively. To reach this limit, the consumption would have to be 460 and 200 g day-1 of mussels collected from the corresponding most contaminated locations.

Conclusions: To maintain, according to EFSA, safe levels of Ni, Cu, Fe and Zn exposure by ingestion of mussels' tissue, an adult should not consume over 970, 460, 460 and 200 g $day^{-1}$ of mussels from the most contaminated stations, respectively.

**Keywords**: Biomonitoring; Tolerable daily intake; Upper Intake Level; Essential metals; Mussel watch

# Effects of different types of selenium supplements used to feed Sanhuang chickens

Liping Liu[1], Qianyu Li[1], Zhangyi Yan[1], Yiwei Li[2]

[1]Beijing Center for Disease Prevention and Control, Beijing 100013, China
[2]Department of Chemistry, North Carolina State University, Raleigh, 27695, USA

**Abstract (poster)**

Purposes: Selenium (Se) is an essential trace element for the human body and plays an important role in maintaining health. Since selenium is mainly obtained through dietary intake, developing Se-enriched foods can help improve the population's selenium consumption. Meat, as an important component of the Chinese diet, can have its tissue selenium levels enhanced by adding Se-containing supplements during feeding. However, due to the narrow health threshold of selenium, excessive intake can be harmful to health. Additionally, selenium exists in various species, each with markedly different health effects. For example, the intake of inorganic selenium such as selenite [Se(IV)] and selenate [Se(VI)] poses health risks. This study focuses on the distribution and occurrence of selenium species in the tissues of Sanhuang chickens fed with different Se-containing supplements, supporting research into the role of selenium in nutritional health.

Methods: Three types of selenium supplements, sodium selenite, Se-containing Cardamine and Se-enriched yeast, were used to feed Sanhuang chickens. The total selenium content in the tissues of the Sanhuang chickens was determined using microwave digestion followed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). High Performance Liquid Chromatography-Inductively Coupled Plasma Mass Spectrometry (HPLC-ICP/MS) was used to analyze and determine the four selenium species in the muscle and liver of Se-enriched Sanhuang chickens after protease digestion: selenate [(Se(VI)], selenocysteine (SeCys), methylselenocysteine (MeSeCys) and selenomethionine (SeMet).

Results: The results showed that the distribution of selenium content in Sanhuang chickens fed with different kinds of selenium supplements was as follows: liver > kidney > spleen > thymus > small intestine > glandular stomach > heart > muscular stomach > chicken breast > chicken leg meat. This indicates that different tissues and organs have varying capacities for selenium accumulation. Among the chickens fed with different Se supplements, those in the Se-enriched yeast group exhibited the highest selenium levels in muscle and other tissues and organs. Selenium speciation analysis revealed that the predominant form of selenium in the chicken breast and leg was SeMet, while SeCys was the main form in the liver. Furthermore, the SeMet content in the muscle and liver of the Se-enriched yeast group was significantly higher than that in the groups fed with other Se-containing supplements.

Conclusion: Supplementing with Se-containing additives affects selenium accumulation in Sanhuang chicken tissues. In particular, feeding Se-enriched yeast significantly increases the overall selenium content, especially the SeMet levels. This study provides a valuable reference for the research on the health benefits of selenium and the production of Se-enriched poultry meat.

**Keywords**: Se-containing supplements; Chicken; Selenium; Selenium speciation

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# theme 6

## geological materials in health and well-being

# Concerning mercury (Hg) levels in the hair of children inhabiting a volcanically active area

Rute Fontes[1], Nádia M. P. Coelho[1], Patrícia V Garcia[2], Armindo S Rodrigues[3]

[1]Faculty of Sciences and Technology, University of the Azores
[2]Faculty of Sciences and Technology, University of the Azores; cE3c - Centre for Ecology, Evolution and Environmental Changes
[3]Institute of Volcanology and Risks Assessment, Faculty of Sciences and Technology, University of the Azores

**Abstract (oral)**

Background: Gaseous elemental mercury (Hg0 or GEM) is an atmospheric form of mercury (Hg) – a toxic heavy metal – naturally released in volcanic environments. Research with wild mice demonstrates that chronic exposure to a hydrothermal volcanic environment leads to the bioaccumulation of Hg in the lungs, but also in both the central (CNS) and peripheric (PNS) nervous systems, with marked indications of neurotoxicity. Studies addressing human exposure to volcanogenic Hg0 are scarce. Hence, its risks are still unknown. This study aims to evaluate the level of exposure to Hg0 in children living in a volcanically active environment.

Methodology and main findings: Two groups of school-aged children (6 to 9 years old) were part of this study: one with children inhabiting a hydrothermal area (exposed group), and another with children inhabiting an area without volcanic activity (non-exposed group). Hair samples were collected from each individual for Hg level analysis. It was found that the levels of Hg in the hair of exposed children were 4.2 times higher than in non-exposed children (≈ 1797.84 ± 454.92 mg $kg^{-1}$ vs. 430.69 ± 66.43 mg $kg^{-1}$, respectively).

Conclusion: Given Hg's vast health risks, the need to monitor the health of populations inhabiting volcanically active areas is highlighted. Because little is known about the fate, modifications, and effects of Hg0 in the human body, particularly regarding its effects on the nervous system in children, the development of further research within the scope is strongly encouraged.

**Keywords**: Volcanism; Soil diffuse degassing; Gaseous elemental mercury (Hg0 or GEM); Bioaccumulation; Neurotoxicity; Neurological disorders

# Influence of crystallochemistry on clayey materials from Santa Maria (Azores, Portugal) properties relevant to be used as healing clays

Fernando Rocha[1], Cristiana Costa[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal

**Abstract (oral)**

The use of natural products as an alternative to drugs composed of chemicals is showing increasing interest. Clayey products are promoted in global markets as therapeutic or aesthetic clays, combining characteristics of medicinal products and cosmetics. From this perspective, it is important to study materials that are in line with this need, namely about the formulation of peloids and/or cosmetics. The Azores archipelago is historically sought after for mud baths, especially on the island of S. Miguel, where volcanic mud has good characteristics but a scarcity of available resources. Thus, residual clay materials from the island of Santa Maria have been studied to evaluate whether they present favourable characteristics for the formulation of peloids. Previous tests on twenty samples, collected throughout the island, have made it possible to consider that they are very favourable for peloid formulations, due to their mineralogical, chemical and technological properties. They showed good potential for being mixed with volcanic muds from S. Miguel. Concerning the availability of resources, the studied deposits show extensive outcrops. However, since special attention must be given to the presence of Heavy Metals, Potential Toxic Elements (PTE), crystallochemical studies were carried out to evaluate the speciation of the main clay minerals, their PTEs contents and also the influence of crystallochemical characteristics on the properties considered relevant for their use in the preparation of peloids and/or dermocosmetics.

**Keywords**: Healing Clays; Santa Maria Island; Properties assessment

# Therapeutic peloids with thermal water from Caldas da Rainha (Portugal)

Carla Marina Bastos[1,2], Fernando Rocha[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal
[2]Exatronic, Lda. Stadium Park, Pavilhão I Zona Industrial de Aveiro, 3800-373 Aveiro, Portugal

## Abstract (oral)

The distinctive mineral composition of thermal waters from Caldas da Rainha (Leiria, Portugal), with total hypersaline mineralization, sulfurous ionic composition and sodium chloride, with a pH of 6.7, has been recognized for its role in the treatment and prevention of rheumatic and musculoskeletal diseases, motivated its use in the formulation of therapeutic peloids, guiding their applicability to health and well-being. A detailed evaluation of the peloid formulations, resulting from the mixture of thermal water with a catalogued bentonite, was carried out, highlighting their physicochemical stability, technological properties and biological characteristics, fundamental to ensure compliance and efficacy in therapeutic applications [1].

To explore the potential of these peloids, studies focused on the analysis of their percutaneous absorption, bioaccessibility and physicochemical stability were conducted, aiming to assess their efficacy in therapeutic applications [2,3]. Percutaneous absorption of calcium, magnesium and trace elements was analyzed using vertical diffusion cells (Franz cells) and human skin membranes. The results highlighted the safety and therapeutic potential of these formulations, demonstrating a minimal permeation of potentially toxic elements and the controlled passage of essential elements, suggesting a favourable safety profile for therapeutic use [2].

Complementary experiments evaluated the bioaccessibility of essential minerals in the peloids and the role of perspiration in facilitating their absorption. Using an experimental model of artificial perspiration, the interaction of the peloid with the skin was simulated when applied in the context of pelotherapy [3]. Some of the essential elements were available in concentrations that may contribute to therapeutic effects, while the solubility of potentially toxic elements was low or undetectable.

These results reinforced the relevance of the thermal waters of Caldas da Rainha in the formulation of therapeutic peloids, supporting their use in therapeutic interventions and health and well-being practices.

**Keywords**: Peloids; Thermal water; Percutaneous absorption; Bioaccessibility

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# Well-studied zeolite – an exceptional mineral as 'magic stone' for the benefit of human health

Wilfried Dathe[1]

[1]Heck Bio-Pharma GmbH. Gerberstraße 15, 73650 Winterbach, Germany

## Abstract (oral)

The term 'magic stone' was introduced by Frederick Mumpton in 1999 for zeolites, crystalline microporous aluminosilicates with remarkable properties of ion exchange, water adsorption and irreversible fixation of harmful substances. The natural Cuban zeolite has undergone intensive mineralogical, chemical and physical testing to ensure that it is also suitable for human use, including oral and topical treatment. For this reason, we prepared different formulations for oral and topical application under the trademark Detoxsan. The Cuban zeolite contains a mixture of the medium-pore 10-membered ring zeolite clinoptilolite and the large-pore 12-membered ring zeolite mordenite. The fundamental research had been focused on the effects of particle size, mineralogical composition, amine and heavy metal binding capacities compared to the internal and external surface of zeolites by using different particle sizes.

The histamine uptake capacity of zeolites having smaller size particles is significantly higher than those larger size particles. Histamine performs pleiotropic effects in human beings as a potent mediator of numerous biological reactions including histamine intolerance, gastric acid production and influences multiple rare diseases. A similar adsorption capacity applies to serotonin (5-HT), another important biogenic amine. It is well known as the 'hormone for fortune' in the brain, but excessive peripheral blood levels provoke amongst others severe diarrhoea. Oral application of a Detoxsan® formulation was able to reduce bowel movements of patients suffering from therapy-refractory diarrhoea. The clinical results show that about 70% of patients benefit from taking this medical device for reducing bowel movements from numerous defecations to normal level – and thereby significantly increasing living quality. While Detoxsan® powder can significantly reduce the symptoms of NET-related diarrhoea, its dosage and duration vary individually.

The positive effect on skin irritations of zeolite paste seems to be due at least partially to the adsorption of histamine (favours inflammation and itching) and water (a prerequisite for microbial growth) by zeolite, and the anhydrous mineral layer protects the inflamed areas from external influences.

Furthermore, zeolite for topical application on skin surface (Detoxsan® Paste) is based on vaseline and contains additionally squalane as a natural lipid component. It adheres to the skin's surface, forms a thin mineral layer, and can reduce skin irritations. The waterless formulation of Detoxsan® Paste covers the skin surface, avoids water and oxygen supply to the irritated skin as a prerequisite for microbial growth of pathogens and acts as an adsorbent for histamine (favours inflammation and itching) and water. Squalane retains water and the elasticity of the skin. It was used for six defined superficial skin lesions and other skin irritations that were not clearly proven, like nail mycoses and acne. In all the cases described, the symptoms of itching and inflammation often accompanying these skin lesions improved significantly. It seems likely that the positive effect of Detoxsan® paste on the healing of skin lesions is due to the combination of the three components of the paste.

**Keywords**: Zeolite; Histamine; Serotonin; Itching; Inflammation

# Pioneering study on the mineral-medicinal properties of Uruguayan thermal waters for therapeutic applications

Lorena Vela[1], Francisco Maraver[1], Francisco Armijo[1], Ana Ernst[2], Sofía da Rocha[3], Pablo Gamazo[3], Elena M. Alvareda Migliaro[3]

[1]Escuela de Hidrología Medica, Facultad de Medicina. Universidad Complutense de Madrid, España.
[2]Medicina General, Club Remeros Salto, Uruguay.
[3]Departamento del Agua, Centro Universitario Regional Litoral Norte, Universidad de la República, Rivera 1350, Salto, Uruguay

## Abstract (oral)

This pioneering study in Uruguay explores the mineral-medicinal properties of thermal waters in the Salto and Paysandú Departments. The findings mark a national milestone, opening avenues for research in balneotherapy and therapeutic applications, thereby enhancing human health and adding value to this natural resource. The COVID-19 pandemic highlighted the need to expand the therapeutic use of thermal waters for physical and mental well-being. In response, Uruguay hosted the 21st edition of Termatalia from October 4 to 6, 2023, in Salto and Paysandú, bringing together experts and stakeholders in the thermal tourism sector. This event fostered academic collaborations among researchers from the Water Department of CENUR Litoral Norte, the University of the Republic (Udelar), and the Professional School of Medical Hydrology and Hydrotherapy at Complutense University of Madrid. The Professional School of Medical Hydrology and Hydrotherapy at the Complutense University of Madrid, established in 1968, is the only institution in Spain recognized for training medical specialists in medical hydrology. The partnership aims to deepen the understanding of the thermal waters in Northern Uruguay and to develop a manual on mineral-medicinal waters for therapeutic purposes. The minero medicinal Vademecum will guide the appropriate use of these uniquely characterized waters in treating various health conditions. Hydrochemical characterization of water samples from seven thermal centers was conducted, presenting promising results for the appropriate therapeutic use of these waters. This study not only contributes to scientific knowledge but also promotes the therapeutic use of thermal waters, enhancing public health and supporting the sustainable development of Uruguay's natural resources.

**Keywords**: Groundwater; Mineral-medicinal; Therapeutic; Uruguay

# Clayey materials for health and wellness

Fernando Rocha[1], Carla Bastos[1,2]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal.
[2]Exatronic, Lda. 3800-373 Aveiro. Portugal

## Abstract (oral)

The use of clays for medicinal, wellness, and aesthetic purposes has been an ancestral practice among mankind, employed topically (in the form of peloids or muds) or by ingestion. Clays are probably the oldest Earth materials used for healing, dating back close to 2 million years. Based on archaeological and written records, clays have played an important role in medicine from the dawn of mankind. In ancient Rome, tablets of 'terra sigillata', mainly consisting of clay, were used for medicinal purposes. Galen, a Roman physician, who lived in the second century AD, was said to have carried thousands of clay 'coins' to the troops to help with their gastrointestinal problems. Modern medicines routinely utilize minerals to aid in the cure, mitigation, or prevention of disease and/or to serve as useful dilutants or fillers in potions or pills. For a long time, a large number of minerals have been used for therapeutic purposes. Clays and clay minerals have been commonly used for this purpose, either for pharmaceutical (in the form of active principle or excipient) or in the direct application in aesthetic medicine (entering the composition of cosmetic products in the form of excipient or active principle). The pharmaceutical and cosmetic industry uses clays in their formulations, subject to prior control before use. Clays are used in pharmaceuticals as excipients or as active substances due to their high retention capacity, colloidal and expansive properties, which are useful for modulating drug release in the organism, their chemical inertia, and low or non-toxicity to the patient. As active substances, they have been mainly used as gastrointestinal protectors, osmotic oral laxatives and antidiarrhoeaics (on oral applications) or as dematological protectors (on topical applications). As excipients, they improve pharmaceuticals' organoleptic characteristics, such as taste, smell and colour, or their physical-chemical properties, such as viscosity, facilitate the preparation of pharmaceutical formulations, and promote the disintegration of pharmaceutical formulations when it is orally administered in the form of pills, capsules, etc. "Peloids", resulting from the mixing of clay and mineral-medicinal water, have been used in many thermal centers/spas, as a distinguished therapeutic modality, "pelotherapy". All over the world, we can find different peloids that can be highlighted by their peculiar chemical and mineralogical composition, physical properties, and also by the biological-metabolic activity of micro-organisms. The majority of these peloids are naturally maturated with the autochthonous water and clays on the outskirts of thermal centers or prepared artificially (paramud), sometimes enhanced with cosmetic ingredients performers, botanical, algae, or diatoms, colored additives, or flavored. Some of these peloids are sold for cosmetic purposes and personal healthcare usage, a parallel business to pelotherapy, and are now getting some relevance on the wellness field and Health Tourism. Some clayey products (such as zeolites and smectites) are presented in the market as natural medicines for ingestion, with a detoxification action and a protective effect on the mucous membrane of the gastrointestinal tract and are certified as a medical device

**Keywords**: Healing minerals; Clayey geomaterials; Geopharmacy; Geomedecine

# Multidimensional exploration of the health risk impacts of geochemical selenium distribution

Liqin Su[1]

[1]National Institute of Environmental Health, Chinese Center for Disease Control and Prevention, Beijing 100050, China

## Abstract (oral)

Selenium (Se) is a trace element characterized by its low abundance and uneven geographical distribution in nature. The relationship between selenium nutritional status, determined by geochemical soil selenium levels, and the risk of various chronic diseases has emerged as a focal point in international research. Utilizing cohorts established and maintained through funding from the U.S. National Institutes of Health (NIH) and the National Natural Science Foundation of China (NSFC), we assessed the selenium burden in rural elderly populations across six regions with varying soil selenium levels in three Chinese provinces. We conducted a multi-dimensional study to investigate the associations between selenium exposure and the prevalence, incidence, and mortality of multiple chronic diseases. Additionally, we explored the interactive effects of geochemical selenium, lead, and cadmium on thyroid function. Our findings indicate that higher selenium exposure may be a protective factor for cognitive function in the elderly. However, higher selenium levels may also be associated with an increased risk of hypertension, dyslipidemia, and diabetes, which is consistent with recent studies conducted in high-selenium populations in the United States and the United Kingdom. In contrast, data from five-year mortality and chronic disease surveillance revealed that in low-selenium regions within the same province, the standardized rates of all-cause mortality, non-accidental total mortality, cardiovascular and cerebrovascular disease mortality, and cancer mortality were higher than those in high-selenium regions within the same province. Moreover, the standardized prevalence rates of stroke, coronary heart disease, diabetes, and hypertension were also higher in low-selenium regions compared to high-selenium regions within the same province. In addition, cross-sectional evidence indicated that high selenium exposure may attenuate thyroid dysfunction caused by lead exposure. Our study highlights the need for more attention to the potential health impacts of geochemical selenium deficiency.

**Keywords**: Selenium in soil; Geochemical elements; Health impacts; Risk of chronic diseases; Mortality Risk

# Rheological characterization of clay/thermo-mineral water and clay/seawater mixtures for thermal treatments and dermoscometic

André Valente[1], Fernando Rocha[1], Denise Terroso[1], Eduardo Ferreira da Silva[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal

**Abstract (oral)**

The study of geological resources for application in health and well-being is an integral part of the novel Medical Geology, and among the most relevant treatments are those that use peloids. The concept of peloid is related to the development of natural products used for therapeutic purposes through a maturation process between clay material and mineralized water. To be suitable for thermal treatment, or even dermoscometic, peloid must have good adhesiveness, easy mashing, and low abrasiveness, which offers a pleasant sensation when applied to human skin. This research shows the rheological results of three residual smectitic soils (Beja, Bena and Monta), from Alentejo, southern Portugal, and the six peloids obtained after the ageing of starting samples with thermo-mineral water from Cabeço de Vide (Beja-T, Bena-T and Monta-T) and with seawater (Beja-S, Bena-S and Monta-S). Furthermore, this work aims to assess the main rheological alterations after the maturation process and the contribution of each water to the beneficiation and development of peloids. The rheological characterization of pre- and post-maturation samples was carried out using the following analysis: viscosity, liquidity and plasticity limits, swelling, oil absorption and abrasiveness.

The rheological characterization of samples showed the influence of the two mineralized waters. Thermo-mineral waters benefited the plasticity index of peloids (44 – 64 % from 33 – 41 % in starting samples) compared to the seawater peloids (31 – 45 %). Regarding the swelling, the values obtained in all peloids were identical to the starting samples (around 40 %). Oil absorption in seawater peloids was lower (near 21 %) than the thermo-mineral water peloids (22 – 30 %) (from 26 – 38 % in starting samples). Concerning the abrasiveness index, it shows higher results in Monta-based samples (between 387 g $m^{-2}$ in Monta-S and 747 g $m^{-2}$ in Monta-T) and lower results in Bena-based samples (between 56 g $m^{-2}$ in Bena and 125 g $m^{-2}$ in Bena-T).

**Keywords**: Peloids; Maturation process; Rheology; Thermal treatments, Dermocosmetic

# Saline muds in pelotherapy: Ria de Aveiro and Ria Formosa saltpans (Portugal)

Lara Almeida[1], Fernando Rocha[1], Carla Candeias[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal.

**Abstract (poster)**

The therapeutic use of geological materials to promote human health and well-being has a long history, dating to ancient times. Practices such as using minerals, muds, and salts in healing rituals and therapies have been part of human culture since the beginning of humankind. In more recent times, while many therapeutic practices have evolved, the application of salted materials, particularly those derived from saline environments, known for their rich mineral content, remains largely underexplored. The present study aims to characterize saltpan mud samples and evaluate the potential for pelotherapy. Four samples were collected from Portuguese saltpans, specifically two in Ria de Aveiro (Marinha de Santiago; Aveiro) and two in Ria Formosa (Tavira and Olhão; Algarve). A comprehensive set of analyses was conducted, including mineral phases identification by X-ray diffraction (XRD), major elements composition by X-ray fluorescence (XRF), particle size distribution by Sedigraph, and particles morphological characterization and semi-quantitative chemical analysis using a scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). Physicochemical parameters (i.e., pH, electrical conductivity (EC), organic matter content (OM), moisture (M)) were determined, along with physical properties such as color. To evaluate samples suitability for pelotherapy, technological tests (e.g., abrasiveness index, oil absorption, Atterberg limits, specific surface area) were performed. Additionally, thermal properties (cooling time and specific heat) were analyzed to infer their ability to retain and transfer heat, a key factor in therapeutic purposes. Results showed that mineral phases identified, and chemical composition were similar across study areas and among samples. Physicochemical parameters indicated a slightly alkaline pH, ranging from 6.96 to 8.38, and an relatively high EC, ranging from 7465 to 26680 $\mu S\ cm^{-1}$. The highest values were observed in samples from Ria Formosa, which is characteristic of saline environments. The OM content was significant (4.75 to 10.01 %), with the highest value recorded in a sample from Ria de Aveiro. These exhibited a grey colour (when dried), whereas those from Ria Formosa displayed a yellowish-brown hue. Technological tests indicated that the samples from Ria Formosa exhibited a suitable abrasiveness index (86 and 138 $g\ m^{-2}$), while those from Ria de Aveiro were near the 200 g m-2 limit. All samples revealed adequate oil absorption capacity. Ria Formosa samples showed a low plasticity index (0.73 and 3.75 %), whereas the Ria de Aveiro samples were close to the minimum required value of 20 %. Specific surface area of Ria de Aveiro samples displayed relatively low values, while those from Ria Formosa met the minimum criterion of 10 $m^2\ g^{-1}$. Thermal properties analysis revealed acceptable specific heat values across all samples. However, cooling times did not fully meet the minimum limit, though several samples approached the threshold, suggesting that with further simple refinements, the cooling process could be effectively optimized. A sample collected at Ria de Aveiro did not exhibit the ideal properties to promote human health and well-being. Still, it was the most promising sample collected to achieve the primary goals of this study. Sedigraph and SEM-EDS analysis are still in progress.

**Keywords**: Sediments; Salted materials; Ria de Aveiro; Ria Formosa; Pelotherapy

# Portuguese georesources for preventive natural therapies – some examples

Carla Candeias[1], Fernando Rocha[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal

**Abstract (poster)**

Georesources, such as mineral-rich thermal waters, marine sediments and therapeutic muds, have long been used in natural preventive healing practices in Portugal. Scientific validation and the combination with modern healthcare practices remain underexplored. This study highlights the therapeutic potential of three different Portuguese georesources used for therapeutic purposes: (1) the hyperthermal mineral waters (68 °C) of São Pedro do Sul, known for their high Si and Li content; (2) the salt-rich muds and brines from Ria Formosa, a Ramsar-protected coastal lagoon; and (3) the organic-rich peloids of the Alentejo coast, characterized by unique microbiological and geochemical profiles. Three areas are used for balneotherapy, thalassotherapy and pelotherapy, with different economic valorization.

Health benefits have been studied through patient surveys and clinical trials, targeting chronic inflammatory diseases (e.g. psoriasis, osteoarthritis). Balneotherapy with São Pedro do Sul waters is known to reduce pain scores in osteoarthritis patients by 40% (VAS scale) after a 14-day regimen, attributed to the neuromodulatory effects of Li and the role of Si in tissues repair. Thalassotherapy protocols with materials from the Ria Formosa improved the skin's barrier function in eczema patients (reduction in TEWL: 25%). At the same time, applications of Alentejo mud relieved muscle stiffness through thermogenic and vasodilatory mechanisms.

Despite their effectiveness, accessibility to these georesources has obstacles. About 70% of thermal facilities are in the north of Portugal, with limited infrastructure in the south of Portugal (Alentejo and Algarve). Cost analyses have shown that community-based programs can reduce patient expenses by 50%. The combined use of traditional health services and preventive care for chronic diseases will potentially reduce pharmaceutical dependency. Challenges include standardizing the quality of materials and ensuring ecological sustainability. Combining treatments will also have a positive impact on wellness tourism. By associating traditional knowledge with evidence-based practice, these therapies can be extended to holistic health models, prioritizing affordability and ecological management.

**Keywords**: Therapeutic georesources; Balneotherapy; Thalassotherapy; Pelotherapy; Portugal

# Technological characterization of lagoon sediments for potential applications in dermocosmetics and healing therapies

Inês Ferreira[1], Fernando Rocha[1], Carla Candeias[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal

**Abstract: (oral)**

The use of geological materials for therapeutic purposes is an ancestral practice, with broad therapeutic benefits, such as rheumatological, dermatological, and cosmetic treatments.

This study evaluated the potential of sediments collected from the bottom of Pateira de Fermentelos lagoon (Portugal) for therapeutic applications, especially in pelotherapy and dermocosmetics. Five samples were collected, sieved to obtain the < 63 µm fraction, and analysed.

The study's methodology included granulometric analysis (wet sieving for the < 63 µm fraction and sedimentation for the < 2 µm fraction), particle morphology (SEM-EDS), mineralogy (XRD), chemical composition (XRF and CEC), technological properties (abrasivity, oil absorption, specific heat, expansibility, consistency limits, index of plasticity, specific surface, cooling time and viscosity) and physicochemical parameters (pH, EC, OM and color). For this presentation, only the technological results will be explained.

Results demonstrated that the samples meet most requirements for dermocosmetic products and pelotherapy applications. The exceptions are only in some methods like the cooling time, with the higher value being 13.5 minutes in sample A5 (acceptable value between 20-30 minutes). In expansibility, the acceptable values are >20%, and the A2 sample has 19.40%, the only one below the limit. Finally, in viscosity, the acceptable values are >4 Pa.s, and the samples below that are A2 (1.41 Pa.s) and A3 (3.90 Pa.s) at 22 °C, and at 40 °C, only A2 is below with 1.97 Pa.s. The results below expectations can be improved with peloid beneficiation. However, the possibility of application requires further study.

**Keywords**: Clays; Pelotherapy; Dermocosmetics; Medical Geology; Preventive treatments

# Special Natural Waters that Heal in the Iberian Peninsula

Carla Sofia Almeida Rocha[1]

[1]Center for Natural Resources and Environment (CERENA), University of Lisbon, Instituto Superior Técnico, Av. Rovisco Pais, Lisboa, 1049-001, Portugal

## Abstract (poster)

According to Dr. João Rafael Mendes Dona, in the "Medical Report on the Medicinal Waters of Cabeço de Vide", 1896, published in "Coimbra Médica", volume XVI, p. 57. the "specificity of the action of these waters, in that order of features, makes us predict that there is an unknown quid, a factor of the brilliant clinical results, which its chemical composition does not explain." The first thermal hospital in the world is located in Caldas da Rainha, Portugal. It was founded in 1485 by Queen Dona Leonor, wife of King Dom João II, during the 15th century. In 1663, Boyle, an English chemist, indicated and patented the solution of violas because it has the property in mineral waters of greening with alkalis and reddish with acid. In 1667, Duclos observed that the iron in mineral waters became evident with the solution of galls, turning black. In 1670, the Paris Academy of Sciences ordered the development of the first chemical analyses of mineral waters. In 1697, Alfonso Limón Montero, professor of medicine at the University of Alcalá de Henares, in Spain, developed the work "Espejo cristalino de las aguas de España". In 1726, Henrique da Fonseca Henriques (Dr. Mirandela), physician of Dom João V, developed the work "Aquilégio Medicinal".

In Portugal until the middle of the 18th century, the sense organs were the only analytical way to characterize water, such as the smell of rotten eggs, the smell of hydrogen sulfide, cold or hot, fluidity, unpleasant taste, and white or iron deposits, while studies and analytical techniques were developed abroad. In 1775, Domenico Vandelli, an Italian professor at the University of Coimbra, was responsible for the first chemical analysis of mineral waters in Portugal, in the Chemical Laboratory of the University, hired by the Marquês de Pombal. In 1820, the sulphurous waters of Cabeço de Vide, in the municipality of Fronteira (Portalegre, Portugal), were among the first Portuguese sulphurous waters to be analysed. The technicians Dr. Tomé Rodrigues Sobral and Dr. Francisco Xavier Pimenta discovered Hyperalkalinity (pH> 11.5) in addition to the sulphurous properties of these natural and medicinal mineral waters. In December 2019, the Hydrogenome project resulted from the cooperation of the General Directorate of Energy and Geology (DGEG) with the National Laboratory of Energy and Geology (LNEG), in Portugal, allowed the recognition of the therapeutic properties of natural, medicinal and thermal mineral waters attributed to specific microbial action in cooperation with chemistry and the geological environment, promoting with greater efficiency the different medicinal therapies of natural thermal waters and medicinal minerals.

In the Iberian Peninsula, the use of therapies involving waters that heal and waters that bring health is a practice that has been used since ancient times. There are approximately 170 occurrences of medicinal waters in the Iberian Peninsula with different therapeutic affections, ranging from sulphurous, fluoridated, calcic, bicarbonate, magnesian, iron, litiniferous, light waters, very mineralized waters, hyposaline, Hyperalkaline (pH>11.5), etc. which promote health and enable the development of study cooperation with chemistry, medicine, biology and geology. Geology is mainly responsible for the entire chemical, microbiological, and thermal system that promotes the health of these healing waters.

**Keywords**: Natural Mineral Water; Iberia Peninsula; Health; Geology; Multivariate data analysis

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# theme 7

## advances in analysis methods and techniques

# Advance Micro-XRF 2D Imaging for multivariate analysis in geosciences and biomedical research

Sofia Barbosa[1], Sofia Pessanha[2], António Dias[2], Pedro Catalão-Moura[2]

[1]GeoBioTec (UNL) - GeoBiosciences, GeoTechnologies and GeoEngineering, Department of Earth Sciences, NOVA School of Science and Technology, NOVA University of Lisbon, Campus FCT-UNL, 2829-516, Caparica, Portugal
[2]Laboratory for Instrumentation, Biomedical Engineering and Radiation Physics (LIBPhys-UNL), Department of Physics, NOVA School of Science and Technology, NOVA University of Lisbon, Campus FCT-UNL, 2829-516, Caparica, Portugal

## Abstract (oral)

Energy Dispersive X-ray Fluorescence (EDXRF) is a non-destructive technique that provides high-resolution (<25 µm) elemental data while preserving sample integrity, which is quite valuable for characterising geological, environmental, and industrial materials. The technique generates high-resolution 2D chemical distribution maps, enabling qualitative and semiquantitative single-element or multi-element analyses. These maps are particularly useful in various research fields, including toxicology, geoenvironmental sciences, and the advanced characterization of minerals and secondary raw materials.

We introduce a specialized image analysis methodology that allows applying multivariate, unsupervised, and supervised classification algorithms, enhancing micro-XRF 2D map interpretation of heterogeneous matrix data. This approach is demonstrated across diverse heterogeneous matrix sample types, including geogenic and urban soils, sediments, and dust, as well as secondary raw materials like phosphogypsum and mining waste. This approach enhances the potential of micro-XRF 2D map analyses by enabling more comprehensive 2D map and multivariate interpretations, allowing identification of elemental associations, and pathfinders that characterize the phenomena under investigation.

**Keywords**: Micro-XRF 2D imaging; Elemental Association; Multivariate Statistics; Pathfinders; Machine Learning & Predictive Modelling

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# The ecological quality status (EcoQS) of the Ilha Grande Bay (SE Brazil)

Maria Virgínia Alves Martins[1], Fabrício Leandro Damasceno[1], Murilo Barros Saibro[1], Egberto Pereira[1], Luiz Guilherme Costa Santos[2], Thaise Senez Melo[1], João Graciano Mendonça Filho[2]

[1]Universidade do Estado do Rio de Janeiro
[2]Universidade Federal

## Abstract (oral)

In recent years, the region surrounding Ilha Grande Bay (BIG) in southeastern Brazil has become a hub of intense urban expansion and economic exploitation driven by urban, tourism, industrial, and port activities. The present work aims to analyses if a foraminiferal morphology-based approach (M) and eDNA-based metabarcoding sequencing (G), respond coherently to gradients of geochemical data, such as total organic carbon (TOC) and metals concentrations (As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, S, Sb, Sn, Tl, V and Zn) among other environmental data (such as temperature, salinity, pH and Eh of the water and sediment), and evaluate coherently the ecological quality status (EcoQS) in the BIG. In the morphological assemblages (M), the density of foraminifera varied between 0.1 x10$^4$ and 3.9 x10$^4$ n°/g and the exp(H'bc) (M), a biotic index based on species diversity, ranged between 2.48-43.32. In the genetic assemblages (G), the density of foraminifera varied between 1.9x104 and 11.8 x104 reads/50 ml and the expH'bc (G), between 23.19 and 129.92. The BIO-ENV analysis was used to identify the environmental parameters that best explained the turnover/difference for each biotic dataset (morphospecies and amplicon sequence variants, ASVs). The Redundancy Analysis (RDA) explained the distribution of the main morphospecies and ASVs as a function of selected environmental parameters that best describe the assemblages' distribution. Statistical analyses reveal that the ASVs and morphospecies diversity and the relative abundance of most taxa decline in response to the environmental stress (ES) gradient related to TOC (0.11-2.57 %) and metals (Pollution Load Index – PLI between 0.6-4.4; modified degree of contamination – mCdeg between 0.6-4.8, and Potential Ecological Risk Index—PERI between 55.6-398.1). The Ecological Quality Ratio (EQR) based on exp(H'bc) (G) and exp(H'bc) (M) revealed differences in EcoQS in BIG, correlated with geochemical and hydrodynamic stressors. Both biotic indices (based on ASVs and morphology) and the geochemical indexes identify the stations near the municipality of Paraty as having the worst EcoQS among the studied sites. This work highlights the importance of molecular analysis and morphological methods in environmental impact studies, in addition to the geochemical and other environmental stressor indicators. It confirms the reliability of foraminiferal metabarcoding in the EcoQS assessment.

**Keywords**: eDNA; Metals; Organic matter enrichment; Pollution; Diversity

# Methodology for developing an Artificial Intelligence application using Google Earth Engine to generate lithological maps

Rhania Rolo[1], Sónia Maria Lima Silva[2], Jorge Medina[1]

[1]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal.
[2]Cartography Department. Faculty of Engineering. Rio de Janeiro State University (UERJ).

## Abstract (oral)

Artificial Intelligence (AI) is revolutionising the geosciences. Driven by technological advances, AI has improved the ability to collect and analyse data on a scale never before possible, allowing professionals in the field to understand the Earth's processes better. One of the geologist's jobs is to build lithological maps used in various activities. Conventional mapping is expensive, time-consuming, and challenging, as is the case with mapping areas that are difficult to access and have vegetation cover. Fortunately, the integration of remote sensing, which allows large amounts of data to be acquired remotely, with machine learning algorithms has generated an efficient means of identifying the geological characteristics of the Earth's crust. This paper presents a methodology for developing an application that integrates the Google Earth Engine (GEE) tool with Python routines to optimise the identification and mapping of different lithologies in a given region. The region chosen as a case study was São Pedro do Sul, in Portugal, associated with the existence of granite massifs and metasediments of the Schist-Grauvacic Complex with the occurrence of the great active fault with alignment Penacova - S. Pedro do Sul - Régua - Chaves - Verín, leading to flows of great distances and depths that condition the hot springs of the geothermal and hydrothermal field. The methodology included: calculating the NDVI vegetation index from multispectral images; calculating temperature from thermal images; automatic image classification using the Random Forest method; developing routines to optimise activities; and validating results in the field. To develop the application in Python, a requirements survey was carried out, and a conceptual data and process model was drawn up. The results of the vegetation index and temperature point to a differentiation in the lithologies present in the area. The Random Forest classification method proved efficient when compared with the existing geological map and validation on the ground. In the future, the application could include spatial data from other satellite systems, such as radar images.

**Keywords**: Artificial intelligence; Remote sensing; Lithological mapping; Google Earth Engine; Image classification; Random Forest.

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# theme 8

## perception and communication of environmental hazards and health risks

# Natural arsenic in Uruguayan groundwater: health risks and community participation.

Paulina Pizzorno[1,2], Mariano Cáceres[2], Josefita Santana[3], Gastón Ruiz[3], Carolina Arbelo[3], Nelly Mañay[2], Valery Bühl[4]

[1]Programa de Posgrado de Facultad de Química, Universidad de la República
[2]Área Toxicología, Facultad de Química, Universidad de la República
[3]Unidad docente asistencial Santoral, Facultad de Medicina, Universidad de la República
[4]Área Química Analítica, Facultad de Química, Universidad de la República

## Abstract (oral)

Arsenic (As) contamination in groundwater is an increasing environmental and public health concern in Uruguay. While 99% of the urban population has access to potable water through the state-owned company OSE, many rural communities rely on unmonitored private wells. Studies conducted by our research group have confirmed elevated arsenic levels in multiple regions, exceeding both the World Health Organization (WHO) guideline of 10 µg $L^{-1}$ and Uruguay's national standard of 20 µg $L^{-1}$.

This study presents findings from San Antonio (Canelones), where an environmental and public health assessment was conducted. The research involved groundwater sampling to measure arsenic concentrations, urinary biomonitoring to evaluate human exposure, and community surveys to assess water usage and awareness of contamination risks.

Water samples were analyzed using Hydride Generation Microwave Plasma Atomic Emission Spectroscopy (HG-MP-AES) for total arsenic determination and Solid Phase Extraction (SPE) combined with HG-MP-AES for arsenic speciation. Risk assessment followed WHO and USEPA methodologies, calculating Cancer Risk (CR) and Hazard Quotient (HQ).

Results showed that 60% of San Antonio's water samples exceeded the national arsenic limit, while 98% surpassed the WHO guideline. Additionally, 95% of residents drink well water, confirming direct exposure. CR values exceeded $1\times10^{-4}$, indicating a significant lifetime cancer risk, while HQ values greater than 1 suggest potential non-cancer health effects, including dermatological and cardiovascular issues. Urinary arsenic biomonitoring further confirmed quantifiable exposure to inorganic arsenic.

A strong emphasis was placed on sharing results with the community to ensure that residents and local authorities were informed and actively involved in addressing arsenic contamination. The research team organized community meetings, workshops, radio programs, and discussions with local health professionals and government officials. Each participant received a personalized report with their water and biomonitoring results. Public forums were also held to discuss findings, risks, and possible mitigation strategies. In addition, the team collaborated with local authorities to address water safety concerns and implemented educational initiatives to inform rural populations about the risks of arsenic and safer water alternatives. Community members played a key role in understanding the local water situation, which led to further discussions with policymakers. These efforts continue through ongoing public consultations, local health collaborations, and policy recommendations planned for the coming months.

This study highlights a major public health issue in rural Uruguay. Community engagement is essential for effectively addressing arsenic contamination, as residents seek knowledge and demand solutions. Future actions should focus on expanding monitoring efforts in other affected areas, developing affordable arsenic removal technologies for rural regions, and strengthening community education programs.

**Keywords**: Arsenic contamination; Public health; Groundwater; Human exposure; Community participation

# Association between long-term exposure to dust $PM_{2.5}$ and blood lipids: a nationwide longitudinal study in China

Qi Wang[1], Xueyan Han[1], Zhaoyang Pan[1], Jian Guo[2,3], Yuanli Liu[1], Teng Wang[1], Tianjia Guan[1]

[1]School of Health Policy and Management, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China, 100730.
[2]Department of Cardiology, State Key Laboratory of Complex Severe and Rare Diseases, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China, 100730.
[3]Medical Research Center, State Key Laboratory of Complex Severe and Rare Diseases, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China, 100730.

## Abstract (oral)

Sand and dust storms have become increasingly serious issues due to the intensified challenges of climate change. However, evidence on the relationship between long-term exposure to dust-sourced fine particulate matter (dust $PM_{2.5}$) and blood lipids is limited, which is crucial for the early prevention of cardiovascular diseases. This study included 292,754 participants (683,759 observations) from a national longitudinal study before 2019. Multivariate linear fixed effects models were used to evaluate the associations between long-term exposure to dust $PM_{2.5}$ and four blood lipid levels. The nonlinear exposure-response relationships between dust $PM_{2.5}$ and blood lipids were also explored. Each interquartile range (IQR) increases in cumulative 6 months exposures to dust $PM_{2.5}$, was associated with 3.32% (95% confidence interval [CI]: 3.02%, 3.63%), 2.04% (95% CI: 1.65%, 2.42%), and 1.11% (95% CI: 0.84%, 1.37%) increases in low-density lipoprotein (LDL-C), triglyceride (TG), and total cholesterol (TCHO) levels, respectively, and a 3.25% (95% CI: 2.94%, 3.56%) decrease in high-density lipoprotein cholesterol (HDL-C) levels. The exposure-response curve for four blood lipid levels mainly was monotonic. Our results suggest long-term exposure to dust $PM_{2.5}$ was deleteriously associated with blood lipids. Measures to mitigate the long-term hazard of dust exposure are imperative to improve adverse cardiovascular outcomes in the future.

**Keywords**: Particulate matter; Sand dust; Blood lipids; Long-term effects; Longitudinal study

# The joint effects of mixture exposure to multiple meteorological factors on step count: a panel study in China

Ziqiang Lin[1], Ming Zhang[2], Wenjun Ma[1]

[1]Department of Public Health and Preventive Medicine, School of Medicine, Jinan University, Guangzhou, China
[2]Department of Biostatistics and Epidemiology, School of Public Health, Shenzhen University Medical School, Shenzhen, Guangdong China

## Abstract (poster)

The public health burden of increasing extreme weather events has been well documented. However, the influence of meteorological factors on physical activity remains limited. Existing mixture effect methods cannot handle cumulative lag effects. Therefore, we developed a quantile g-computation distributed lag non-linear model (QG-DLNM) by embedding a DLNM into quantile g-computation to allow for the concurrent consideration of both cumulated lag effects and mixture effects. We gathered repeated measurement data from Henan Province in China to investigate both the individual impact of meteorological factors on step counts using a DLNM and the joint effect using the QG-DLNM. We projected future step counts linked to temperature and relative humidity changes driven by climate change under three scenarios from the sixth phase of the Coupled Model Intercomparison Project. Our findings indicate inverse U-shaped associations for temperature, wind speed, and mixture exposure with step counts, peaking at 11.6°C in temperature, 2.7m $s^{-1}$ in wind speed, and 30$^{th}$ percentile in mixture exposure. However, there are negative associations between relative humidity and rainfall with step counts. Additionally, relative humidity possesses the highest weight in the joint effect (49% contribution). Compared to 2022, future step counts are projected to decrease due to temperature changes, while increasing due to relative humidity changes. However, the projections indicate a decrease in step counts when considering future temperature and humidity changes driven by climate change. Our findings may suggest that global warming will negatively influence Chinese physical activity.

**Keywords**: Mixture exposure; Joint effect; Meteorological factors; Physical activity; Quantile g-computation distributed lag non-linear model

# Polycyclic aromatic hydrocarbons concentrations in carbon blacks of tyre formulations and their potential environmental impact

Diogo Machado[1,2], Cristiana Paiva[2,3], Ruth Pereira[1,2], Anabela Cachada[2,3]

[1]Biology Department, Faculty of Sciences, University of Porto, Porto, Portugal
[2]GreenUPorto & INOV4AGRO - Sustainable Agrifood Production Research Centre, Campus de Vairão, Vairão, Portugal
[3]Department of Geosciences, Environment and Spatial Plannings, Faculty of Sciences, University of Porto, Rua Campo Alegre s/n, 4169-007, Porto, Portugal

## Abstract (poster)

Polycyclic Aromatic Hydrocarbons (PAHs) are a widespread class of organic pollutants, mainly formed through the incomplete combustion of organic materials. These compounds have been found in various environmental matrices but are also present in man-made materials like carbon blacks (CBs). CBs are manufactured for several uses, one of which is as a colourant and filler of tyre rubber. Manufacturing of CBs involves the combustion of hydrocarbon feedstocks, which can form PAHs.

It has been hypothesised that releasing PAHs from CBs derived from tyre abrasion can have environmental implications. However, the bioavailability of the PAHs in tyre wear particles may be limited, and the hazards of these residues might have been greatly overestimated. Scientific research into this theme has diminished in the latter decades, with most of the bibliography being from the 1970s and 80s, and it's focused on the total content of PAHs in CBs. Recently, a study published by the European Commission provided data about concentrations of PAHs in plastic and rubber articles and proposed a migration measurement method to assess human exposure.

Aiming to compile data regarding previous characterisations of CBs, a bibliographic search was made regarding PAHs concentrations and analytical methods reported. Afterwards, the PAHs belonging to the United States Environmental Protection Agency top 16 priority list were extracted from three different CBs by Soxhlet extraction with toluene or a mixture of dichloromethane and hexane, and analysed by GC/MS. The results showed that PAHs are present in CBs analysed, but their concentrations were inconsistent with previous results. Also, it was observed that levels and profiles of individual PAHs are different among the three CBs tested. However, this analysis continues not to provide insights into the (bio)availability of PAHs from CBs, with the next step being the study of the interaction of CBs with environmental matrices (soil) and their contribution to PAHs to biota, to assess potential risks to soil-dwelling sensitive species.

**Keywords**: Biological indicators; Microbial community; Agricultural practices; Plant protection products

# Analysis of the availability and bioaccessibility of Pb, Zn, Cd, and Cu in smelting slags collected in the Ribeira Valley Region (Brazil)

Valéria Guimarães Silvestre Rodrigues[1], Stéfanie Crescêncio[1], Eduardo Ferreira da Silva[2]

[1]Department of Geotechnical Engineering, São Carlos School of Engineering, University of São Paulo, Brazil
[2]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal

## Abstract (poster)

For a long time, slags resulting from smelting were considered inert and often used for paving streets and gardens. However, numerous studies have demonstrated that smelting slags are not inert but sources of contamination, susceptible to the solubilization and leaching of potentially toxic metals and metalloids. In this context, the main objective of this research was to evaluate whether the potentially toxic metals present in smelting slag (originating from the smelting of lead ore), which was deposited directly on the soil and dirt roads in the municipality of Adrianópolis (PR, Brazil), in the Ribeira Valley region, were prone to leaching, solubilization, and bioaccessibility. To this end, total concentrations of lead (Pb), zinc (Zn), copper (Cu), and cadmium (Cd) were determined, along with the geoaccumulation index (Igeo) established by Müller (1969) and the ecological risk potential (Eir) established by Håkanson (1980). Additionally, leaching and solubilization tests were conducted according to the Brazilian standards ABNT NBR 10.005 and 10.006:2004, and bioaccessibility was assessed following EPA 1340 guidelines. The slag exhibited the following average chemical composition: Cu (2,827.25 mg $kg^{-1}$); Pb (41,900.00 mg $kg^{-1}$); Zn (117,975.80 mg $kg^{-1}$); and Cd (47.25 mg $kg^{-1}$). For all analyzed metals, the geoaccumulation index indicated class 6 contamination (extremely contaminated), with values of 10.68 for Pb, 10.14 for Zn, 5.41 for Cu, and 5.24 for Cd. Regarding ecological risk, Pb, Zn, and Cd posed a very high ecological risk, while Cu presented a high risk. In the leaching test, Zn exhibited the highest concentration in the leachate (156.67 mg $L^{-1}$). The concentration of Pb in the leachate (1.67 mg $L^{-1}$) exceeded the limit established by ABNT 10.004:2004 (1.00 mg $L^{-1}$), indicating its leachability. However, Cd and Cu concentrations did not exceed the regulatory threshold in the leaching test. In the solubilization test, Pb and Cd exceeded the limits set by ABNT 10.004:2004. The Pb concentration detected in the solubilized extract (0.22 mg $L^{-1}$) was 22 times higher than the regulatory threshold, while Cd also exceeded the ABNT 10.004:2004 limit (0.03 mg $L^{-1}$). In contrast, Zn concentration in the solubilized extract (0.037 mg $L^{-1}$) remained below the regulatory threshold, and Cu was not detected. The bioaccessibility test conducted on the slag yielded the following average values: 510.53 mg $L^{-1}$ for Pb, 644.67 mg $L^{-1}$ for Zn, 18.34 mg $L^{-1}$ for Cu, and 0.17 mg $L^{-1}$ for Cd. Based on these results, it is evident that slags are not inert and therefore require proper disposal. Pb and Zn in this sample are bioaccessible and leachable, while Cd and Pb are solubilizable. The slag can still be found on the dirt road connecting Adrianópolis to Vila Mota and within the beneficiation plant. Thus, proper disposal is necessary.

**Keywords**: Lead ore; Smelting; Leaching; Solubilization; Bioaccessibility

# Analysis of the availability and bioavailability of potentially toxic metals in mining tailings – Ribeira Valley (Brazil)

Valéria Guimarães Silvestre Rodrigues[1], Isabela Monici Raimondi Nauerth[1], Eduardo Ferreira da Silva[2]

[1]Department of Geotechnical Engineering, São Carlos School of Engineering, University of São Paulo, Brazil
[2]GeoBioTec Research Center, Department of Geosciences, University of Aveiro. Campus de Santiago, 3810-193 Aveiro, Portugal

**Abstract: (poster)**

Inappropriate mine waste dumps can expose potentially toxic metals (PTMs) to interaction with water or wind over the years, acting as active sources with the potential to endanger both local and downstream ecosystems. Thus, this study attempted to assess the possibility that the tailings remaining on the Ribeira de Iguape River riverbank (in Adrianópolis city, Brazil) act as an effective source of PTM contamination and their ability to cause toxic effects on organisms. This waste was exposed to weathering until 2006, when it was covered by a thin clay layer and undergrowth. However, it did not represent an adequate final disposal, since the layer was vulnerable to rain erosion (with several points uncovered) and the area lacked proper isolation. The superficial tailings samples (0-80 cm, named S1 to S5) were collected with an auger (Dutch model) throughout the deposit (coordinates 24°40'30''S and 48°54'00''W). Several tests were performed to investigate the physical, chemical, and mineralogical characteristics of the tailings samples. The main non-metallic mineralogical phases identified by XRD spectra and SEM/EDS analyses in the tailings samples involved dolomite ($MgCa(CO_3)_2$), calcite ($CaCO_3$), barite ($BaSO_4$), and quartz ($SiO_2$). Dolomite and calcite, as carbonate rocks, are the main constituents of the host rocks of the metal shafts in the Ribeira Valley region. The pH of the samples ranged from 7.6 to 8.0, characterizing the waste as neutral to alkaline. The average PTM pseudo-total concentration followed the decreasing order: Zn (7724.7 mg $kg^{-1}$) > Pb (5236.7 mg $kg^{-1}$) > Cu (115.1 mg $kg^{-1}$) > Ni (65.6 mg $kg^{-1}$) > Cr (54.5 mg $kg^{-1}$) > Cd (29.9 mg $kg^{-1}$). According to sequential extraction results, the more mobile and available fractions (exchangeable + bound to carbonate fractions) decreased in the order Pb > Cd > Zn ≈ Ni > Cu > Cr, highlighting the position of Pb and noting that the order of mobility is not the same as the pseudo-total concentration. PTM mobilization through direct contact with water (considering different pH conditions) was supported by solubilization and leaching tests, with Pb and Cd in concentrations above the regulatory thresholds. The ecotoxicological analysis evidenced the bioavailability of PTMs, demonstrating an acute toxic effect of PTMs released from the tailings (through contact with distilled water) on the microcrustacean *Daphnia similis*. Even in well-diluted samples (3.1% of the solubilized fraction), PTMs were sufficient to cause acute effects, with Pb having a significant influence. Therefore, even after approximately 25 years since mining activities were deactivated, the tailings deposited in the municipality of Adrianópolis constitute an active source of PTM introduction into the environment.

**Keywords**: Contamination; Lixiviation; Solubilization; Ecotoxicology; Tailings

# Modelling spatial non-stationarity of industrial point emission sources' impact on regional cancer prevalence

Mei Lei[1], Yuan Xu[2]

[1]Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences
[2]University of Chinese Academy of Sciences

## Abstract (oral)

Accurate assessment of the impact of industrial pollution on cancer incidence at the regional scale is critical for developing effective prevention strategies. However, conventional models face significant limitations in predicting the causal relationship between industrial point source emissions and cancer prevalence due to spatial non-stationarity and data scarcity in complex environmental systems. To address these challenges, this study proposes a novel spatially coupled modelling framework that integrates industrial point source emission data with regional cancer incidence records. By employing multi-scale geographically weighted regression (MGWR), the model elucidates the spatially heterogeneous effects of industrial pollution on cancer distribution, thereby overcoming the constraints of global estimation approaches. This approach achieves two key advancements: First, it establishes a robust methodological framework for evaluating spatial correlations between industrial pollution sources and cancer epidemiology, enhancing analytical rigour and interpretability. Second, by replacing global assumptions with localized estimations, the model identifies critical exposure hotspots where industrial emissions exhibit statistically significant associations with cancer clusters. These findings enable targeted environmental health interventions by prioritizing high-risk zones for pollution control and cancer surveillance. This research contributes to environmental epidemiology by providing (1) a transferable methodology for spatial health risk assessment and (2) empirical evidence supporting policy-driven mitigation of industrial pollution impacts. The localized risk mapping technique developed here offers health authorities a precision tool for resource allocation in cancer prevention programs.

**Keywords**: Industrial pollution; Multiscale geographically weighted regression; Spatial non-stationarity; Exposure assessment

# Medical Geology courses as environmental education tools: our experience in the Faculty of Chemistry

Teresa Heller[1], Nelly Mañay[1]

[1]Facultad de Química, Universidad de la Republica, Av. Gral. Flores 2124, 11800 Montevideo, Uruguay

**Abstract (poster)**

Future professionals and researchers in biosciences and geosciences need to be accurately informed about both natural and anthropogenic factors affecting the environment.

This presentation aims to show the suitability of the Medical Geology courses of our Toxicology Area for Environmental Education of Chemistry and Geosciences students at the University level.

Our methodology consists in the description of the essential characteristics of Environmental Education and relates them to the contents and teaching dynamics of our two main Medical Geology courses, which have been held annually by our Toxicology Area starting in 2004. These optional courses are taken by advanced undergraduate and postgraduate Chemistry and Geosciences students of our University who want to deepen their environmental formation in theory and practice. The students are presented with the basic principles and international examples of Medical Geology and Environmental Toxicology, including the Ecohealth approach among other environmental sciences.

Our results show the ability of our teaching practices in Medical Geology to foster the formation of our students through targeted training, leading to the acquisition of environmental awareness, involvement, knowledge, and capacity for action in their specific future professional fields and roles. This is shown by the quality of their presentations in our Seminars.

In conclusion, we want to highlight the importance of continuing to develop Medical Geology University Education as a motor of advancement for sustainable environmental management through the necessary professional and research capacity building.

**Keywords**: Medical Geology; Environmental Education; Course dynamics

# Evaluation of the ecological quality status of Guanabara Bay (SE Brazil) based on geochemical and biotic indicators

Maria Virgínia Alves Martins[1], Fabrício Leandro Damasceno[1], Murilo Barros Saibro[1], Wellen Fernanda Louzada Castelo[1], Egberto Pereira[1], Rubens Figueira[2], Wania Duleba[2]

[1]Universidade do Estado do Rio de Janeiro
[2]Universidade de São Paulo

**Abstract: (oral)**

Guanabara Bay, covering approximately 380 km², is one of the largest coastal systems in Brazil. Temiminós Indians inhabited the region, but after its discovery by the Portuguese explorer expedition in 1502, the population density increased considerably, especially after the second half of the twentieth century. Guanabara Bay is experiencing progressive environmental degradation, primarily due to siltation, eutrophication, and pollution from urban, agricultural, economic, industrial, and port activities. This work is based on the study of surface sediment samples collected at 98 sites on the margins of Guanabara Bay. In these locations, physicochemical parameters in the water and sedimentological data (textural and geochemical) and living and dead foraminifera were recorded. The ecological quality status (EcoQS) of Guanabara Bay was assessed based on the Exp(H'bc) biotic index, which is related to species diversity for both living (L) and dead (D) foraminifera. The most significant dissimilarities between Exp(H'bc)-L and Exp(H'bc)-D were found in the outer region of the bay, since the latter includes foraminiferal tests from the continental shelf. The statistical comparison between the Exp(H'bc)-L values, total organic carbon (TOC), and geochemical indices, such as the Pollution Load Index (PLI) and the Potential Ecological Risk Index (PERI), based on the concentration of potentially toxic chemical elements (PTEs), shows general agreement. The results show that the worst EcoQS are located north of the Governador Island – São Gonçalo City axis and in the port region of Rio de Janeiro and Niteroi, and that their analysis should be based on the living foraminifera assemblages. These results underscore the need to protect this coastal system's environment and emphasize the importance of ongoing monitoring and protective policies using the proposed biological indicators.

**Keywords**: Metals; Organic matter; Pollution; Foraminifera; Ecological Indices

MEDGEO 25 ISEG

# special session

## geo-health: present and future

# Mechanism of selenium alleviating rice cadmium stress and its effect on cadmium accumulation in rice

Yingchun Wei[1], Ruizhe Guan[1], Linyong Chen[1], Xianyao Chu[1], Zhiguo Wang[2], Huiqin Huang[3], Mingwei Yu[4]

[1]Zhejiang Institute of Geosciences, China
[2]No.7 Geological Party of Zhejiang Province, China
[3]Zhejiang Institute of Marine Geology Survey, China
[4]Jiaxing Municipal Bureau of Natural Resources and Planning, China

## Abstract (poster)

To explore the alleviating mechanism of selenium(Se) on cadmium(Cd) stress in rice and the effect of cadmium accumulation in rice, weathered black shale soil in Western Zhejiang Province, China, was collected for pot experiments on rice cultivation, by injecting different concentrations of Se 0, 0.4, 0.8, 1.2, 1.6 and 2.0 mg $kg^{-1}$ and Cd (0, 2, 4, 8 mg $kg^{-1}$) solutions. The result indicates that Se inhibited the absorption of Cd by rice. When soil Se concentration ranges from 0.4 mg $kg^{-1}$ to 0.8 mg $kg^{-1}$, the inhibitory effect of rice on soil Cd absorption is most significant which is attributed to the variation of antioxidant enzymes in rice by the induction of Se, such as by inhibiting the increase of Superoxide Dismutase (SOD) activity induced by Cd in rice, exciting Catalase (CAT) and Ascorbate Peroxidase (APX), thereby improving rice stress resistance and alleviating its toxicity from Cd. While soil Se concentration increases to 0.4-0.8mg $kg^{-1}$, the activity of CAT and APX reaches its highest value. Generally, the photosynthetic rate and photochemical efficiency of rice leaves decrease with an increase in Cd concentration; however, the increase in Se concentration can reverse this trend. It demonstrates that Se can alleviate Cd stress on rice photosynthesis by preserving the maximum photochemical efficiency and photochemical performance index of rice leaves. Overall, within an appropriate concentration range, addition of Se can effectively reduce the accumulation of rice Cd and alleviate the toxic effect of Cd on the growth of rice. Based on geo-health perspective, in future, the technique of Se increasing and Cd decreasing in rice can generate significant health effects and social benefits.

**Keywords**: Selenium; Cadmium; Alleviate; Rice; Toxic

# Identification and prevention for cadmium risk in paddy fields system of black shale series based on health geological survey

Ruizhe Guan[1], Linyong Chen[1], Xianyao Chu[1], Zhiguo Wang[2], Huiqin Huang[2], Mingwei Yu[4], Yingchun Wei[1]

[1]Zhejiang Institute of Geosciences, China
[2]No.7 Geological Party of Zhejiang Province- China
[3]Zhejiang Institute of Marine Geology Survey- China
[4]Jiaxing Municipal Bureau of Natural Resources and Planning, China

## Abstract (poster)

Health geological survey work in China has found that the ecological risk of regional cadmium-polluted paddy fields was controlled by the black shale series, which is rich in cadmium, iron-based minerals, and organic matter, in western Zhejiang Province. The issue has become an increasingly pressing social concern. Currently, the study on soil cadmium pollution of the black shale series area mainly focuses on pollution evaluation, and so on, and there is little research on the mechanisms of cadmium migration and its main loaded minerals to paddy fields in the black shale series area. This paper selects the paddy field system in the black shale series area of western Zhejiang as the study object. It investigates the cadmium isotope fractionation and transport mechanism under the interaction of iron-based minerals and organic matter at the critical redox environment interface. Based on long-term in-situ monitoring in the fields, the researcher recognizes the dynamic redox interface of water-rock reaction in the black shale layer, the disturbance of the sediment from the downstream water system, and the rice rhizosphere with different pollution levels. This paper analyzes the occurrence forms and isotopic composition characteristics of iron-based minerals and cadmium elements and reveals the transformation mechanism of iron-based minerals and the cadmium reaction mechanism at the interface of iron minerals. Combined with the in-situ monitoring technique of microelectrode and diffusive gradients in thin films (DGT), the study focuses on the changes of iron forms during the dynamic redox process in the rice rhizosphere and the mechanism of its impact on the cadmium transport in the rice rhizosphere, Which has great significance to the risk control of cadmium pollution in paddy fields of the black shale series area.

**Keywords**: Health Geological Survey; Black shales; Paddy field system; Mineral interface; Cadmium transport

# Characterization of cadmium hyperaccumulators in China: taxonomic patterns and phytoremediation potential in metalliferous mining regions

Xiaofeng Zhao[1,2,3], Jiufen Liu[1,2,3]

[1]Comprehensive Survey Command Center for Natural Resources, China Geological Survey, Beijing 100055, China
[2]School of Earth Science and Resources, China University of Geosciences, Beijing 100083, China
[3]Key Laboratory of Coupling Process and Effect of Natural Resources Elements, Beijing 100055, China

## Abstract (oral)

China possesses abundant mineral resources, but prolonged anthropogenic mining activities in certain regions have led to elevated heavy metal concentrations in soils surrounding mining areas and metallogenic belts. Through long-term evolutionary adaptation to these metal-enriched environments, specific plant species have developed remarkable tolerance (metal-tolerant plants) or exceptional accumulation capacities (hyperaccumulators) for heavy metals, demonstrating significant potential for phytoremediation applications. This study systematically analyzed Cd-accumulating plant species (characterized by Cd concentrations ≥10 mg $kg^{-1}$ in aboveground tissues) reported in Chinese scientific literature from 2004 to 2021 through comprehensive database searches. The investigation focused on taxonomic classification, life forms, geographical distribution, and habitat characteristics to establish a reference database for identifying Cd hyperaccumulators.

The compiled dataset comprises 340 distinct records of Cd-accumulating plants spanning 55 botanical families. The Asteraceae family exhibited the highest representation with 135 entries. Herbaceous plants (including annual, biennial, and perennial species) dominated the life form spectrum, accounting for 283 records with superior metal accumulation capacities. Notably, 180 documented cases originated from lead-zinc mining regions characterized by rich floral diversity and prolonged open-pit mining histories. These areas typically present long-term Cd-contaminated soils that facilitate the evolution of metal-adapted flora.

The findings suggest that selected species from the 340 identified Cd-accumulating plants warrant further investigation through controlled cultivation experiments, quantitative accumulation verification, and multi-generational inheritance studies. Such systematic approaches could facilitate the discovery of novel Cd hyperaccumulators with enhanced phytoremediation potential for practical environmental applications.

**Keywords**: Cadmium hyperaccumulators; Phytoremediation potential; Chinese flora characterization; Metalliferous soils

# Impact of Mining and industrial activities on Black Soil in Northeast China

Jiufen Liu[1,2,3], Xiaofeng Zhao[1,2,3], Changhe Wei[4]

[1]Comprehensive Survey Command Center for Natural Resources, China Geological Survey, Beijing 100055, China
[2]School of Earth Science and Resources, China University of Geosciences, Beijing 100083, China
[3]Key Laboratory of Coupling Process and Effect of Natural Resources Elements, Beijing 100055, China
[4]School of Mining and Geomatics Engineering, Hebei University of Engineering, Handan 056038, China

## Abstract (oral)

The black soil region of northeastern China is an important base for national food security, and parts of the region are exposed to environmental risks from mining and industrial activities. This study investigates the spatial agglomeration patterns of pollution-related enterprises, particularly mining activities (non-ferrous metal mining and petroleum refining) and chemical manufacturing, and their impacts on soil quality in surrounding agricultural lands. Utilizing multi-source geographical big data and GIS spatial analysis (e.g., Ripley's K function and kernel density estimation), 2,151 enterprises were analyzed within the black soil region. The results show that non-ferrous metal mining and petroleum refining exhibit significant spatial clustering, with non-ferrous metal mining having the widest area of influence, accounting for about 3.0% of the black soil area. Although the number of chemical manufacturing enterprises is the largest, the total agricultural land impacted is smaller than that of non-ferrous metal mining enterprises due to their relatively small impact area. The risk of soil contamination on agricultural land in the black soil region is predominantly non-risk. In contrast, the area of agricultural land in the high-risk zone accounts for 0.43% of the total area. The high-risk zone is mainly affected by the non-ferrous metal mining industry and is clustered in the southern and western parts of the Montenegrin subregion. The medium-risk zone is mainly located at the periphery of the high-risk zone and extends to the surrounding areas due to the relatively weak industrial activities and pollutant emission intensity compared to the high-risk zone. These findings highlight the key role of industrial agglomeration and pollutant emission intensity in shaping soil contamination risk. This study emphasizes the need for monitoring and source control at mining and industrial enterprises to safeguard soil health and sustainable agriculture.

**Keywords**: Black soil region; Mining and industrial activities; Non-ferrous metal mining; Petroleum refining; Soil pollution risk; Spatial agglomeration

# Geochemical characteristics and the health risk assessment of thallium in water and soil of Ion- Adsorption Rare Earth Mines and their surrounding areas in Southern Jiangxi Region, China

Siwen Liu[1,2], Dawen Liu[1,2], Qing Sun[1], Jixin Wei[1,3], Chenge Ma[1]

[1]National Research Center for Geoanalysis. No.26 Baiwanzhuang Street Xicheng District, Beijing 100037, China
[2]Key Laboratory of Ecogeochemistry, Ministry of Natural Resources, Beijing 100037, China
[3]China University of Geosciences (Beijing)

## Abstract (oral)

Thallium (Tl), a highly toxic heavy metal with significant bioaccumulation potential, poses severe risks to ecosystems and human health. While previous studies have primarily focused on Tl contamination from industrial activities and sulfide mining, limited attention has been given to its geochemical behavior in ion-adsorption rare earth mining areas. This study investigates the geological distribution, migration mechanisms, and health risks of Tl in soils and waters surrounding the rare earth mine in Southern Jiangxi Region, China, a region with over 50 years of mining history.

Soil and water samples were analyzed using inductively coupled plasma mass spectrometry (ICP-MS). Results revealed elevated Tl concentrations in soils, ranging from 0.2 to 8.4 μg $g^{-1}$ (average 2.2 μg $g^{-1}$), exceeding global and Chinese background values of 0.1~0.8 μg $g^{-1}$ and 0.3~1.2 μg $g^{-1}$, respectively. The highest contamination was observed in mining and tailing zones, with an average Tl concentration of 4.1 μg $g^{-1}$. In water bodies, Tl levels averaged 3.6 μg $L^{-1}$ (range: 0.07~11.9 μg $L^{-1}$), surpassing China's industrial wastewater discharge standard of 2 μg $L^{-1}$.

Geochemical analyses identified Tl speciation as primarily ionic and organic-bound, with migration influenced by weathering processes, soil pH, and organic matter content. Hydrological conditions further facilitated Tl transport through dissolution and adsorption mechanisms.

Health risks were assessed using the USEPA Hazard Quotient (HQ) methodology. The HQ values indicated significant exposure risks for local residents, particularly through consumption of contaminated groundwater, which may lead to long-term neurological and reproductive health impacts. This study underscores the urgent need for targeted remediation strategies, including periodic groundwater monitoring to track Tl mobility, soil stabilization techniques such as pH adjustment and organic amendments, and community health surveillance programs to mitigate chronic exposure.

The findings provide critical insights for policymakers to address Tl contamination in rare earth mining regions, balancing resource exploitation with environmental sustainability and public health safeguards.

**Keywords**: Thallium; Ion absorption REE mines; Geochemical characterisation; Health risks

# Comprehensive Environmental Characteristics and Significance of Typical Longevity Villages in the Qinling Mountains

Jun Zhao- Xi'an[1], Peng Wang -Xi'an[1]

[1]Xi'an Geological Survey Center, China Geological Survey,

Abstract (poster)

Based on the environmental research of longevity villages in the Qinling Mountains area, construct a comprehensive environmental characteristic system of longevity villages to provide a basis for improving the living health level of the similar regions and building a health care industry.

Taking the environment of Jinxing Village, a typical longevity village in the Qinling Mountains, and Yinwan Village, a nearby non-longevity village in Zhashui County as the research objects, samples of rocks, soils, main crops and human hair are collected, and characteristics such as negative oxygen ions and environmental radon are measured. Appropriate analysis methods are adopted. A comparative analysis of the environmental characteristics of longevity villages is conducted, and a health atlas of longevity environments is established.

The rocks in Jinxing Village have higher contents of Pb, Li, K, and Cd, and lower contents of Cr, Ni, S, and Fe. In the soil of Jinxing Village, elements such as Mo, Ni, Cr, and As are significantly enriched, while $Na_2O$, Li, and organic matter are depleted. The water quality in Jinxing Village is alkaline, relatively enriched in Mo, B, Cr, and Ca, and relatively depleted in Mn, V, Al, Pb, and Co. The crops in Jinxing Village generally contain more F, Zn, I, Mo, Se, V, and Si, and are depleted in potentially toxic elements Pb, Cd, and Li. The population in Jinxing Village contains higher contents of Sn, Se, Mn, and Cd. In conclusion, the environment of longevity villages in the Qinling Mountains area has relatively high contents of Zn, I, Mo, Se, V, Sn, B, and Cr, relatively low contents of Pb, Cd, Li, Co, Mn, and Al, and moderate contents of F, P, Mg, Fe, Na, and Ca. This is the spectrum of longevity elements in the sedimentary rock area of the Qinling Mountains.

Compared with the environment of non-longevity villages, the element combinations in longevity villages in the Qinling Mountains area are significantly different. This research is a systematic study of the environment of longevity villages and is of great significance for improving the living health level of similar areas.

**Keywords**: Qinling Mountains area; Longevity villages; Environmental characteristics; Health atlas; Living health level

# Human health risks and antagonistic effects of cadmium and selenium in a geochemically high-background area

Qifeng Tang[1,2]

[1]National Research Center for GeoAnalysis, China Geological Survey (CGS)
[2]Key Laboratory of Eco-geochemistry, Ministry of Natural Resources (MNR)

## Abstract (oral)

Cadmium (Cd) exposure poses significant health risks, particularly in geochemically high-background areas. However, selenium (Se) may counteract Cd toxicity, mitigating its adverse effects. This study examines the distribution of Cd and Se, ecological risks, and health impacts in a black shale region of northwestern Zhejiang. Systematic sampling was conducted in bedrock, soils, drinking water, crops, and human biological samples (hair and urine).

Results show that the highest Cd and Se concentrations are found in the Precambrian Hetang Formation black shales. Soil analysis indicates that while all farmland meets Se-rich criteria, over 30% of agricultural soils exceed Cd risk thresholds. In rice samples, Se levels consistently meet the Se-rich food standard, but Cd concentrations surpass the safety limit in 30% of cases. Speciation analysis reveals the high bioavailability of both elements, leading to significant uptake by crops.

Despite increased urinary Cd (U-Cd) levels in local residents, biomarkers of kidney damage, such as urinary creatinine (U-Cr) and N-acetyl-β-D-glucosaminidase (U-NAG), remain low. Human hair samples exhibit elevated Se and Zn, but Cd and Ni levels are relatively low, suggesting that Se may play a protective role against Cd toxicity. This study provides new insights into the natural antagonistic interactions between Cd and Se, offering potential applications in environmental health risk management and geochemical health assessments.

**Keywords**: Black shale; Geochemically High-background; GeoHealth; Selenium-cadmium antagonism; Environmental geochemistry

# Increasing cases of non-communicable diseases in mining areas of Ghana: is it a lifestyle or hidden players at work?

Emmanuel Arhin[1], Bright Karim-Abdallah[1], Christiana Baah[2]

[1]University of Energy and Natural Resources, Sunyani - Berekum Rd, Fiapre, Sunyani, Ghana
[2]Tafo Government Hospital, Kumasi, Gana

## Abstract (oral)

Ghana's mining industry, mainly Artisanal and Small-Scale Gold Mining (ASGM), is significant in driving economic growth and development, contributing substantially to the country's Gross Domestic Product (GDP) and export revenue. ASGM contributes over 40% of the country's gold production. However, current ASGM practices have neglected responsible mining operations, resulting in environmental degradation and adverse health impacts. The presumed notion that specific trace elements, such as those originating from sulphide minerals, exert an influence on noncommunicable diseases (NCDs) prompted the researchers to examine arsenic (As), lead (Pb), copper (Cu), and zinc (Zn) in 449 soil samples from four designated regions where mining and agriculture serve as the primary sources of sustenance for the residents. The samples were collected 30 cm below the humic layer to ascertain the trace elements for subsequent chemical analysis. Results obtained from ICP-MS analysis were compared with the globally accepted baseline values. A pollution load index (PLI) and Geo-accumulation index (Igeo) were used to determine the pollution status across the four sampled areas. The calculated PLI for As, Pb, Cu and Zn was 1.01, indicating moderate pollution levels. In contrast, Igeo indicated moderate-to-heavy pollution levels; 84.35% -95.79% of elements departed from the accepted baseline values, highlighting hidden dangers posed by these pollutants on population health within the study areas. Arsenic was consistently higher than other elements and is also known to cause NCDs like diabetes mellitus, hypertension, and cardiovascular diseases. The paper concludes that mineral imbalances, among other factors, are evident in the geochemical environment. Therefore, collaborations between Geoscientists and Medical healthcare professionals can pinpoint the regions with a high prevalence of diseases, leading to the development of effective strategies for mitigating Non-Communicable Diseases.

**Keywords**: Potential harmful element; Pollution status; Health Risks; Arsenic; Trace elements

# Insights into the approach for source apportionment of trace metals in riparian soils

Lu Sun[1]

[1]China Institute of Geo-Environment Monitoring

## Abstract (oral)

The apportionment of sources of trace metals in riparian soils is of great concern for watershed management. The spatial heterogeneity of trace metals in riparian soils over large-scale catchments poses challenges in their sources identification. Selecting Baiyangdian Lake Basin as a case study, we used an integrated approach of geochemical analysis and receptor models to quantify the sources' apportionment of trace metals in riparian soils. The results showed that the varied spatial distribution of lithogenic sources and the sedimentary environment primarily governed the heterogeneity of the geochemical characteristics of riparian soils and, thus, the distribution of metals. Land use activity increased the soil disturbance and resulted in metal redistribution in the riparian zone. This work is particularly significant due to its integrated approach for effectively identifying and apportioning the sources of trace metals at the riparian scale. It is suggested that soil parent material dominantly contributed to most elements, among which Cr, Ni, and As are a completely geogenic source. At the same time, Cd, Cu, Pb, and Zn also had considerable contributions from anthropogenic sources. Hg appeared to be the only element majorly influenced by human emissions within the study region. Methodologically, our study provides the insight that a comprehensive understanding of soil geogenic characteristics and receptor model application could make a reasonable source apportionment result of soil trace metals in riparian scale.

**Keywords**: Riparian soil; Trace metals; Geochemical characteristics; Source apportionment

# Geo-Health Survey: methodology research and application

Dawen Liu[1], Siwen Liu[1], Qifeng Tang[1], Taotao Yan[1]

[1]National Research Center for Geo-Analysis, China Geological Survey

## Abstract (oral)

Geo-Health is one applied sub-geological discipline that studies the processes, laws and effects of geological factor impacts related to Human Health. It focuses on the Geological Factors that are related to human health. The first and main task of Geo-Health is to clear the distribution of these geological factors in nature. A geo-health survey can be used to achieve this task. In order to establish the Geo-health survey Methodology, firstly, the paper discusses the key geological indicators, the reference value for each indicator, and the technical routine map for Geo-Health Survey. Then, a case study was conducted in China and Cambodia to demonstrate the application of the Geo-Health Survey Methodology.

**Keywords**: Geo-Health; Geo-Health Survey; Methodology; geological factors; Human Health

# Geochemical gene characteristics of Pu'er tea in Yunnan Province, Southwest China

Taotao Yan[1], Qingjie Gong[2], Dawen Liu[1], Qifeng Tang[1], Shengchao Xu[2]

[1]National Research Center for Geo-Analysis
[2]China University of Geosciences (Beijing)

## Abstract (oral)

As a typical representative of dark tea, one of China's five major tea categories, Yunnan Pu'er tea is renowned for its significant health benefits. Under the support of the Chinese Geo-health Survey Project, this study selected three different tea-growing regions in Yunnan (BD, YP, and XG) as the research objects. It employed geochemical gene technology to perform coding analysis on Pu'er tea and its growth soil. The key findings are summarized as follows: 1) Lithogene (LG_CR) analysis indicates that the soil in the BD region belongs to the "11-type", that in the YP region is classified as the "21-type", and that in the XG region is categorized as the "22-type". 2) Weathering geochemical gene analysis reveals that the soils in the BD and YP tea-growing regions exhibit pronounced weathering characteristics. In contrast, the soil in the XG region demonstrates moderate weathering with relatively weaker weathering effects. 3) Metallogene (MGAu) analysis shows that there are no significant mineralization anomalies in the soils of the BD and YP regions. Still, the soil in the XG region exhibits relatively notable mineralization anomalies. By integrating the research results on trace elements in Pu'er tea and its growing soil, it can be inferred that the content and combination characteristics of trace elements in Pu'er tea are primarily influenced by factors such as soil-forming parent material and the degree of weathering. Moreover, Pu'er tea has a pronounced enrichment effect for health-promoting elements. Through the study of the geochemical genes in Pu'er tea, not only can the reasons for the differences in Pu'er teas from different origins be elucidated, but also, with the ultilization of geochemical big data, scientific evidence and technical support can be provided for the selection of optimal tea-growing areas.

**Keywords**: Geochemical gene; Pu'er tea; Geochemical big data; Geo-health Survey

# Progress and prospects of China's Geo-Health Survey

Zhanhui Li[1], Dawen Liu[2], Jing Jin[1], Siwen Liu[2], Qifeng Tang[2], Jun Zhao[3], Taotao Yan[2]

[1]China Geological Survey, Beijing 100037, China
[2]National Research Center for Geo-Analysis, China Geological Survey, Beijing 100037, China
[3]Xi'an Geological Survey Center, China Geological Survey, Xi'an 710054, China

**Abstract (oral)**

Over the past five years, the China Geological Survey (CGS) has pioneered the development of Geo-Health surveys, an interdisciplinary initiative that aims to bridge geological environments and public health. Leveraging extensive hydrogeological and geochemical datasets from prior national surveys, CGS has established a robust technical framework and database through pilot studies in over 10 representative regions across China. These regions include high-risk areas, such as drinking water-endemic disease zones (e.g., areas with arsenic and fluoride contamination hotspots), longevity regions with unique geochemical signatures, and catchments affected by mining. The surveys integrate advanced geospatial analysis, environmental monitoring, and health risk assessments to systematically evaluate factors influencing human health, including beneficial elements (e.g., selenium), harmful elements (e.g., arsenic, cadmium), geomagnetic fields, and natural radioactivity.

Key achievements of the Geo-Health initiative include methodological innovations such as standardized multi-scale sampling protocols, element speciation analysis, and predictive health impact models. These tools have directly informed policy decisions, supporting national spatial planning, functional agriculture development, and environmental remediation in mining-intensive areas. Additionally, CGS has fostered international collaboration with leading institutions to harmonize methodologies and promote global data-sharing, enhancing cross-border research on geochemical health risks.

Looking ahead, the Geo-Health survey will prioritize the refinement of a dynamic "survey-evaluation-monitoring-zoning" system to address emerging challenges like urbanization-driven pollution and climate change impacts. By integrating real-time data collection with predictive analytics, this system aims to provide actionable insights for mitigating health risks and guiding sustainable land-use practices. The initiative highlights the crucial role of geoscience in protecting public health while striking a balance between resource exploitation and environmental sustainability.

**Keywords**: Geo-Health survey; Beneficial Elements; Harmful Elements; Environmental health; Geochemical mapping

# Certified Reference Materials for atmospheric dustfall: applications in environmental monitoring and heavy metal analysis

An Ziyi[1]

[1]National Research Center for Geoanalysis, Chinese Academy of Geological Science, Beijing 100037, P. R. China

**Abstract (oral)**

The indoor dust particles and their associated heavy metals present significant health risks. The lack of certified reference materials (CRMs) has limited the accuracy and comparability of pollutant measurements. This study aims to support the development of CRMs for environmental monitoring through the collection, characterization, and standardization of dustfall samples. Samples were collected from urban and suburban areas in Beijing, Shandong and Shanxi by vacuuming or sweeping. Microstructure analysis was performed by scanning electron microscopy (SEM), while chemical composition was determined by inductively coupled plasma mass spectrometry (ICP-MS), atomic fluorescence spectrometry (AFS), and gas chromatography-mass spectrometry (GC-MS) after microwave and acid-assisted water bath digestion. The results showed that most atmospheric dustfall particles were between 0.054 and 0.074 mm in size, with considerable variability in elemental composition. Sodium (Na) was found to be elevated in indoor environments, cadmium (Cd) contamination was generally low. At the same time, arsenic (As), lead (Pb) and mercury (Hg) concentrations were significantly higher in industrial areas. Homogeneity assessments and CRM validation confirmed the suitability of the developed dustfall CRM for use in environmental monitoring and quality assurance. This study provides a framework for systematically developing atmospheric dustfall CRMs in China, contributing to more accurate pollutant analysis and improved understanding of environmental contamination.

**Keywords**: Indoor Dust; Heavy Metals; Health Risks; Certified Reference Materials (CRMs)

# Weaving of culture, health and land: resilient healing and intelligent landscape design for Puge County People's Hospital in Liangshan Prefecture, Sichuan Province, China

Chunlin Bian[1], Gang Meng[1], Xiaofeng Cai[2]

[1]Tongji University
[2]Xichang University

## Abstract (poster)

Under the guidance of the "Healthy China" strategy, the construction of therapeutic landscapes in comprehensive hospitals within southwestern ethnic minority regions faces both new opportunities and significant challenges. The critical issue is integrating modern medical concepts with local ethnic cultures to create healing landscape spaces that meet users' physical and psychological rehabilitation needs while preserving regional characteristics. Using Puge County Hospital in Liangshan Prefecture, Sichuan Province, as a case study, this paper explores applying evidence-based design theory to integrate traditional folk customs with digital landscapes. It proposes a multi-objective design matrix to plan a human-centred "Metaverse Healing Landscape" that reconnects people with nature. The goal is to provide a therapeutic space that facilitates physical and mental well-being while immersing users in local culture, offering a valuable case study for building healthy cities in Western ethnic minority regions.

**Keywords**: Therapeutic landscapes; Southwest ethnic regions; Regional cultural landscapes; Urban renewal; Medical Metaverse

# Mainstreaming indigenous health practices: implications for geophagia

Lawrence Diko Makia[1]

[1]Department of Earth Sciences, University of Venda, South Africa

## Abstract (oral)

Indigenous Peoples (IP) conceptualize health from the perspective of a balance between physical, mental, emotional, and spiritual wellness. Inherent in this premise is the continuum of IP's interactions with and dependence on nature for its well-being (food, healthcare, shelter, etc). The use of geomaterials (soil, rocks, minerals, water) by IPs is well documented in the literature. Nonetheless, the lack of consensus among various stakeholders (Indigenous health practitioners, researchers, policymakers, and regulatory bodies such as the WHO, etc.) on the health benefits and/or detrimental effects of geomaterials continues to negatively impact indigenous health practices' mainstreaming. Literature further suggests that support for indigenous health practices depends on the nature and extent of collaboration between Indigenous Peoples (IPs) and other stakeholders. The current study reflects on lessons from the transdisciplinary approach adopted by the African Clays and Clay Minerals Research Group (ACCRG) in addressing the practice of geophagia in Africa. The initiative sought to establish common ground among all stakeholders by integrating diverse knowledge and perspectives. However, the sacred nature of certain indigenous geophagic practices was identified as a major deterrent to the extent to which knowledge sharing could be realized. Against this backdrop, this study recommends a pro-indigenous health approach to engagements with Indigenous Peoples (IPs) as a plausible strategy to encourage knowledge co-creation and sharing.

**Keywords**: Indigenous Knowledge System; Geophagia; Beliefs; Collaboration; Alternative medicine

# Jose A Centeno International Center for Medical Geology Research in Nigeria: updates and opportunities for training

K'tso Nghargbu[1]

JACMEDGEO Center, Nasarawa State University, Keffi, Nigeria

**Abstract (oral)**

Medical Geology is an emerging field in Africa with numerous prospects for growth. In Nigeria we have the first Center for Medical Geology Research of the World located in Nasarawa State University, Keffi, and named after past President of IMGA, Prof. Dr. Jose A Centeno. The Center has developed a curriculum for post graduate studies that seeks to train specialists in the science of harmful and therapeutic geologic processes and materials. Apart from geomedical diseases such as silicosis, coal miners pneumonoconiosis, podoconiosis and a host of others, there are several natural geomedical resources in Nigeria such as thermo mineral springs, medicinal clays, muds, and peloids with huge prospects for setting up a Balneological Center where students of medical geology and the College of Health Sciences can be trained on the science of balneogeology, balneoeconomics, balneology, and balneotherapy (art and science of treating diseases such as diabetes, cancers, dermatological, cardiovascular and gynecological diseases as well as other post-traumatic ailments using balneological resources). Twenty-five (25) pioneer students have been inducted into the Center and lectures have commenced with graduation periods ranging from twelve to forty-eight months depending on Program category. The Solid Minerals Development Fund (SMDF) of the Federal Republic of Nigeria recently endowed a Professorial Chair on Medical Geology in honour of a founding father of the discipline, Professor Robert Barry Finkelman. The objective of this paper is to discuss existing opportunities for the growth of medical geology in terms of training of students and its practical application in Nasarawa State University.

**Keywords**: Nasarawa State University, Training, Balneology, Medical Geology, Diseases, Professorial Chair

# Association between long-term exposure to fine particulate matter from sand dust storms and small airway dysfunction

Hailu Zhu[1], Xueyan Han[1], Zhaoyang Pan[1], Ke Huang[2], Tianjia Guan[1], Ting Yang[2], Chen Wang[3]

[1]School of Health Policy and Management, Chinese Academy of Medical Sciences and Peking Union Medical College
[2]National Center for Respiratory Diseases; State Key Laboratory of Respiratory Health and Multimorbidity; National Clinical Research Center for Respiratory Diseases; Institute of Respiratory Medicine, Chinese Academy of Medical Sciences; Department of P
[3]Chinese Academy of Medical Sciences and Peking Union Medical College

## Abstract (oral)

Rationale: Despite growing concern about the health effects of dust-sourced fine particulate matter (dust $PM_{2.5}$), especially in the context of climate change, the respiratory health effect has not been well characterized. Investigating the impact of dust $PM_{2.5}$ on small airway dysfunction (SAD) is important for early prevention, as SAD represents an early stage of airway obstruction and it is potentially reversible.

Objectives: To evaluate dose-response associations and effect modifications of long-term exposure to dust $PM_{2.5}$ with risks of SAD on a national scale.

Methods: SAD were identified based on lung function data from the China Pulmonary Health Study (N = 50,326). Logistic regression and multivariable linear models were used to quantify the associations between long-term dust $PM_{2.5}$ and SAD, as well as lung function parameters, respectively. Stratified analyses were performed based on demographic characteristics.

Results: An interquartile range (IQR) increment in long-term dust $PM_{2.5}$ concentration was associated with the increased risk of SAD (Odds ratio [OR]:1.18, 95% confidence interval [CI]:1.08, 1.28) and SAD without airflow obstruction (OR: 1.24, 95% CI: 1.10, 1.39). We also found that dust $PM_{2.5}$ exposure was significantly associated with a decrease in pre- and post-bronchodilator lung function. Individuals with lower levels of education were found to be more vulnerable.

Conclusion: We found significant associations of long-term dust $PM_{2.5}$ exposure with higher risk of SAD and decreased lung function, which call for awareness of the harm of fine dust particles on early-stage lung impairment. Studies on the countermeasures of respiratory hazard caused by SDS are warranted.

**Keywords**: Sand dust storm; Dust exposure; Small airway; Lung function

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