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Book of Abstracts

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Use of zero valent iron nanoparticle for in situ chemical reduction of hexavalent chromium in contaminated soils

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In the environment, chromium is mainly found in two oxidation states: Cr(VI) and Cr(III). Cr(VI) is relatively mobile in the environment and is extremely toxic, mutagenic [1,2], teratogenic [3] and carcinogenic [4,5]. In contrast, Cr(III) exhibits relatively low toxicity [6] and is a necessary nutrient for humans and animals [7,8]. Therefore, the reduction of Cr(VI) to Cr(III) is environmentally friendly, and can be used for the remediation of Cr(VI) contaminated sites. Thus, the in situ chemical reduction of hexavalent chromium by the nanoparticle of zero valent iron (nZVI) in contaminated soils near a galvanic zone in northern Italy characterized by an excessive presence of Cr(VI) and other heavy metals has made the object of our research. Experiments were performed on soil samples collected from an industrial site where a nickel contamination, caused by a long-term productive activity, was also verified. The influence of reducing agents amount with respect to chromium content and the effectiveness of deoxygenation of the slurry were discussed. The soil was fully characterized before and after each test, and sequential extractions were performed to assess chemico-physical modifications and evaluate metals mobility induced by washing. Results show that the reducing agent successfully lowered the amount of Cr(VI) in the soil below the threshold allowed by Italian Environmental Regulation for industrial reuse. Cr(VI) reduction by colloidal nZVI proved to be effective: the civil reuse of soil [Cr(VI) < 2 mg/kg] was only achieved using colloidal nZVI within 60 min adopting a nZVI/Cr(VI)) molar ratio of 30. The reducing treatment resulted in an increase in the amount of chromium in the oxide–hydroxide fraction,thus confirming a mechanism of chromium-iron hydroxides precipitation. In addition, a decrease of nickel (Ni) and lead (Pb) content in soil was also observed when acidic conditions were established.

Keywords: Hexavalent chromium, Contaminated soil, Chemical reduction, Nano zero-valent iron.

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Phosphates from the Kotchari deposit, Burkina Faso.

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Samples of phosphorites from different occurrences of the Kotchari deposits, Burkina Faso, were studied. They are phosphorites that are fine-grained with small quantities of clay. The chemical analyses by XRF indicate a CaO content of 35.98 to 41.33 wt%. and a P2O5 contents of 26.85 to 30.75 wt%.

The XRD patterns shows that the major phases are Carbonate-Fluorapatite (Francolite), Hydroxyapatite and alpha-Quartz. They coexist with minor phases that are Wavellite and Maricite. Small quantities of phyllosilicates, smectite and Illite, are also detected. The quantities of phases were obtained by Rietveld refinements with the MAUD software, using reference phases from usual databases. The

obtained fits are satisfactorily, although the significant occurrence of peaks overlapping and broadening. In this study, quantitative Rietveld analysis has shown its effectiveness in accurately identifying and quantifying the mineralogical composition of phosphorites.

FTIR analyses further validate the identification of mineral phases. They show typical bands from phosphates groups in structures. Bands of carbonates groups are also detected and a band is correlated with the occurrence of structural F in Francolite. The relative Intensities of some bands from P-O bonds are related to the crystallinity index of main phosphate minerals. Values of the crystallinity index are slightly above the medium values, that is correlated with the partial substitution of carbonate groups in phosphate crystallographic sites, and with the occurrence of structural Fluor ions. The economic importance of the Kotchari deposits for soil fertilization in agriculture is recognized, and they were the subject of successive mapping and survey works. However, the medium crystallinity index is a disadvantage since it reduces the kinetic of phosphor assimilation in agricultural soils, needing complementary researches.

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Simulation of water transfers at the Soil-Plant-Atmosphere interface in unsaturated soil

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Atmospheric conditions such as air temperature, wind speed, evapotranspiration, and relative humidity have an influence on the surface soil moisture. This communication presents a modelling of water transfers in unsaturated soil, as well as the numerical simulation of these transfers. The model takes into account the physical and hydrodynamic characteristics of unsaturated soils that interact with atmospheric parameters.
Literature research has contributed to the development of a physical model and a mathematical model based on mass and energy transfers as well as the thermodynamics of irreversible processes. The results obtained allow for predicting, using a computational code, the spatiotemporal evolution of soil water content based on atmospheric conditions and physical characteristics (density, porosity, particle size) as well as soil hydrodynamics (desorption isotherm, soil-water characteristic curve, saturated permeability, unsaturated permeability). Understanding the evolution of this water content over time and space is important data that contributes to optimal plant water management.

Keywords: Atmospheric conditions, Surface soil moisture, mathematical modelling, simulation, hydrodynamics

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Evolution of stresses and deformations in a road embankment in unsaturated, low-swelling soil subjected to hydro-mechanical pressures

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We present simulation results of the evolution of stresses and strains in an unsaturated low-swell soil road embankment subjected to hydro-mechanical pressures using the finite element code CODE_BRIGHT. We assume that this bitumen-bearing backfill follows the Barcelona thermo-elasto-plastic model (BBM-TEP). This model describes the thermo-hydro-mechanical (THM) behavior of unsaturated fine soils based on variations in net stress and suction. Using this simulation, the analysis focuses on the collapse of road structures, generally due to the poor quality of the materials used, but also to natural phenomena such as capillary rise, and anthropogenic phenomena such as overloading. The paper shows that imbibition by upwelling induces an increase in the degree of saturation of over 50% in the lower part of the structure, and deformations of up to ten centimetres in amplitude when surcharges are added to the embankment surface. This paper also highlights the behavior of unsaturated soils, such as the decrease in void index with increasing effective stress or suction, and the increase in suction with increasing effective stress.

Keywords: low-swelling soil, road fill, hydro-mechanical pressures, stresses, deformations.

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Comparative assessment of the concentration of radioactive materials in natural sources relevant to mining activities in the Niger Republic using two measurement techniques

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Naturally Occurring Radioactive Materials (NORMs) have always been present in a variety of concentrations in every part of the earth's mantle and in the tissue of every living being.\nNatural radioactivity can be found almost everywhere; in soil, public water supplies, soil and atmosphere. NORMs give rise to a measurable exposure to human beings. In the present study, soil samples and water sample were collected from two different sites in Niger Republic COMINAK and SOMAIR. The soil samples have been analysed using high resolution gamma-ray spectrometry and Neutron Activation Analysis. Water samples were analysed using high-resolution gamma-ray spectrometry only. From the measured gamma-ray spectra, the activity concentrations were determined for two series (238U and 232Th) and one non-series (40K) radio nuclides. The activity concentrations of 238-U and 232-Th were determined from the average concentration of nuclides [Pb-214 (295.2keV; 19.20%), Pb-214(351.9keV; 37.10%), Bi-214 (609.3keV; 46.90%), Bi-214 (1120.2keV; 15.04%) and Bi-214 (1764.49 keV; 15.90%)] and [Pb-212 (238.6keV; 43.6%), Pb-212 (300.09 keV; 3.18%), and Ac-228 (911.2keV; 25.8%), Ac-228 (968.9keV; 15.8%), Ac-228 (338.32 keV; 11.27%)] respectively. The activity concentrations of 40-K were determined directly by measurement of the gamma-ray transitions at 1460.8keV (100%).\nThe obtained results confirm that one of the samples (soil COMINAK) is more radioactive than the soil SOMAIR samples and the results are going closer for the two techniques NMGS and TNAA except the thorium in the soil sample for SOMAIR.

Keywords: NORM, Gamma-ray spectrometry, Neutron Activation, Uranium mining

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Mining Problems in Africa

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Mining activities in Africa have significant environmental and health concern due to the improper disposal of mining waste. This waste contaminates soil, water and ecosystems posing a serious risk to biodiversity and local communities. To tackle these challenges, innovative waste management strategies are needed. In this study, heavy metals like copper, lead, and zinc from mining waste materials were bio-leach in a controlled bioreactors with Bacillus subtilis as metal binding bacteria. The pH, temperature, nutrient levels, and metal concentrations were determined by constant sampling. The measured concentration of heavy metals, was lead (Pb), copper (Cu), and zinc (Zn), with concentrations measured at 26.4 mg/kg, 8.55 mg/kg, and 91.79 mg/kg, respectively. The pH of the bioleaching system was adjusted and maintained at an acidic level (around pH 2) to create optimal conditions for the selected bioleaching microorganisms. The temperature was within 30℃ to 50℃, ensuring that the temperature favored microbial activity with adequate oxygen supply was maintained throughout the experiment, supporting the microbial oxidation of metal sulfides. Over the course of the bioleaching process, regular sampling and analysis of the leachate indicated a substantial reduction in heavy metal concentrations. After 30 days of bioleaching, Pb concentrations decreased to 24.74 mg/kg, Cu concentrations decreased to 6.62 mg/kg, and Zn concentrations decreased to 86.88 mg/kg. Analysis of the solid residues revealed significant changes in mineralogy and chemical composition. X-ray diffraction (XRD) analysis showed the transformation of metal sulfides into less insoluble forms. In conclusion, the bioleaching experiment successfully reduced heavy metal concentrations in mining waste, making it a promising method for managing and remediating contaminated mining sites. This study suggests that further optimization and scale-up of this process could lead to environmentally friendly solutions for mining waste management.

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Enhancing Precipitation Data Accuracy in Burkina Faso: A Comparative Analysis of Satellite-Based Products and Ground Measurements, with Soil Moisture Integration

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This paper investigates the quality of long-period precipitation data in Burkina Faso by integrating ground measurements from the Agence Nationale de la Météorologie (ANAM) with satellite-derived precipitation products such as PERSIANN and IMERG data. The primary objectives are to detect rainfall events, assess measured quantities, and identify outliers or erroneous data in the precipitation records. The study employs a comprehensive comparison approach to evaluate the accuracy and reliability of different satellite precipitation products against ground-based observations. To enhance the precision of precipitation data, ESA Climate Change Initiative Plus Soil Moisture data are introduced as a complementary dataset. A bottom-up approach is applied, utilizing soil moisture data to estimate precipitation quantities and refining the detection of rainfall events. Special attention is given to the correction of biases, particularly in regions characterized by sandy soils within tropical zones. The paper highlights the significance of integrating soil moisture information for improving the quality of precipitation data and addresses the challenges and advantages associated with this approach. The findings contribute to the understanding of the strengths and limitations of satellite-based precipitation products in a region with diverse soil characteristics, offering valuable insights for hydrological modeling, water resource management, and climate studies in Burkina Faso and similar tropical environments.

Keyword: ground measurements, satellite precipitation products, soi-moisture, bottom-up approach, missing data

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Advanced Characterization of Disordered Mesoporous Solids

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Mesoporous solids have found wide uses in catalysis, adsorption, molecular separations, gas and energy storage, among others. Indeed, precise structure-function relations of guest molecules in pores are rightly obtained when accurate knowledge of the confining space is available. At present, most approaches for pore characterization consider disordered porous materials as individual collection of pores where fluid phase transition occurring in one pore has no effect on adjacent pores. However, pore interconnectivity renders fluid phase behavior in one pore dependent on the phase state in its neighboring pore. We show systematically how a model of statistical chain of pores can be applied for solid-liquid phase transitions of porous solids. By creating a kernel-based approach incorporating a variable non-frozen layer thickness between solid core and pore wall and eliminating any a priori assumption of phase transition occurring by metastable or equilibrium transition, we refine the thermoporometry characterization technique. For verification, we show how this approach works well with ordered materials like MCM-41 porous silica and reveals disorder in SBA-15 materials. This approach can be extended to other phase transition phenomena such as gas adsorption.

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Fluid Phase Equilibria in Geometrically Disordered Mesoporous Materials

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Mesoporous solids exhibit structural disorder which strongly influences confined fluid properties. This renders quantification of structural disorder and its correlation with physical properties of confined matter a necessary step towards their optimization in practical applications. In this work, we present advances made in the understanding of correlations between the phase state and geometric disorder in nanoporous solids. We overview the recently developed statistical theory for phase transitions in a minimalistic model of disordered pore networks represented by the linear chains of pores with statistical disorder. Furthermore, we show that correlating its predictions with various experimental observations, the model gives notable insight into collective phenomena in phase-transition processes in disordered materials and is capable of explaining self-consistently the majority of the experimental results obtained for gas–liquid and solid–liquid equilibria in mesoporous solids. We also show how a newly-introduced interconnectivity parameter of the pore network can be assessed to describe the morphology of porous solids.

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Energy recovery from low-value agricultural residues for biochar production during cooking using a multifunction family oven

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The main source of energy for many African families is firewood. Exploitation of this resource is at the root of deforestation, leading to accelerated environmental degradation, with its corollaries of climate change and soil impoverishment. The approach proposed in this paper has a dual objective, namely to provide an alternative energy production technique for household needs, and to contribute to the sustainable management of soil fertilization. The device used is a multifunctional furnace comprising three chambers: a combustion chamber, a pyrolysis chamber, and an insulation chamber. This simplified pyrolysis system for biomass with no market value (cotton stalks, maize cobs, rice husks) produces energy for cooking and, at the same time, biochar for soil improvement. The biochar obtained after pyrolysis is a vegetable coal that differs from energy coal. Biochar is produced at a temperature in excess of 500℃, whereas energy coal is produced at less than 300℃. Biochar helps to improve agricultural yields, as it contains macropores that enable it to house nutrients and then release them slowly to the plant. It also has a high-water absorption capacity thanks to its pores. This paper presents the process optimization approach and highlights the benefits of the proposed technology for sustainable soil and environmental management.