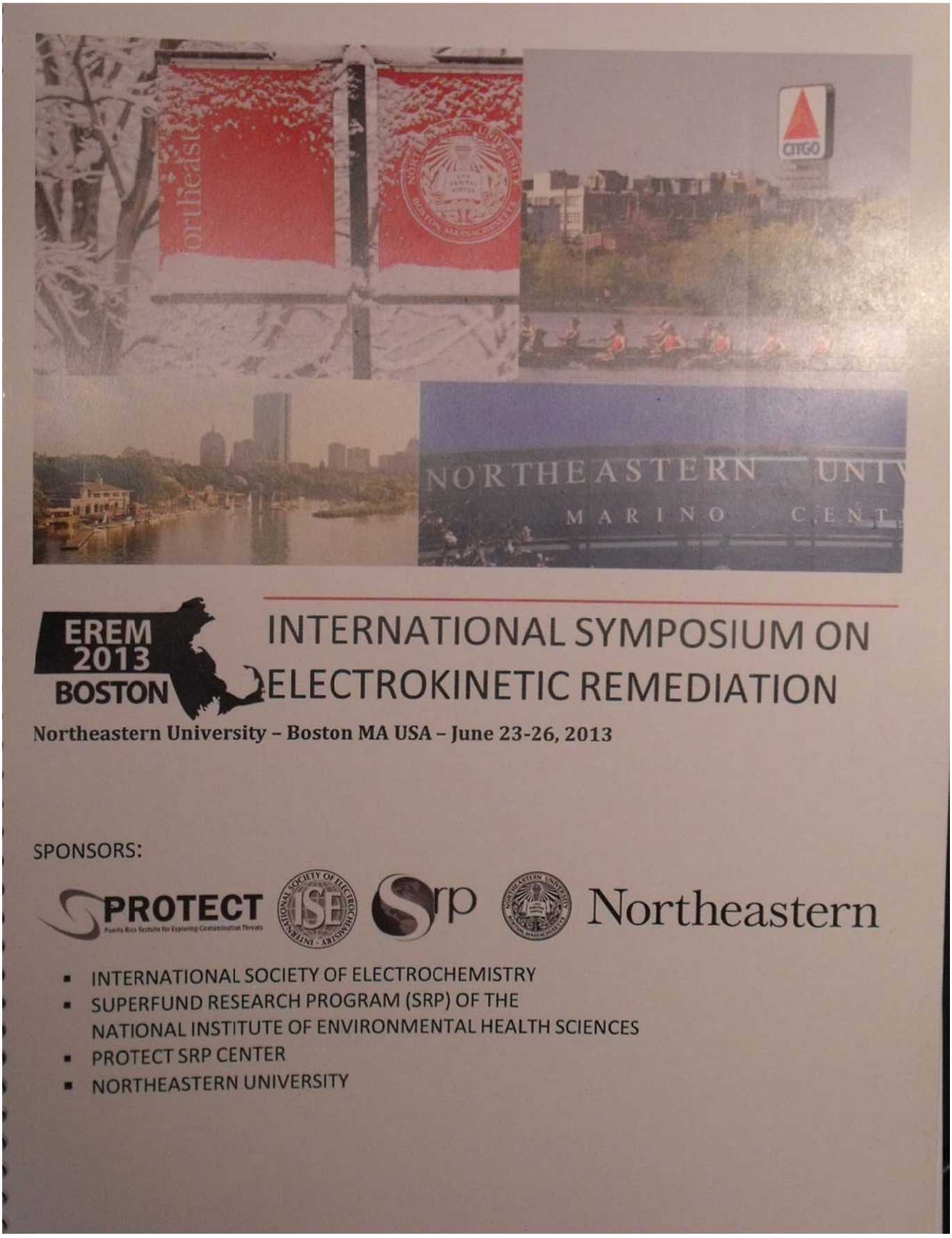
Proceedings



AGENDA[2]

Sunday June 23

18:00 – 19:30 **Reception**

Monday June 24

7:45 – 8:30 **Conference Check-In and Continental Breakfast**

8:30 – 8:50 **Welcome**

8:50 – 9:00 **Opening Remarks**
Nadine Aubry, Dean of Engineering, Northeastern University

9:00 - 9:45 **Keynote Lecture**
Electroremediation: Origins and Efficacy
Ronald Probstein, Ford Professor of Engineering Emeritus, Massachusetts Institute of Technology

9:45 – 10:00 **Break**

10:00 – 12:00 **Session 1 – Metals Removal**
Session Chairs:
- Sibel Pamukcu - Lehigh University, United States
- Mohammed R. Haroun - The Petroleum Institute, The United Arab Emirates

10:00 – 10:15
Simultaneous Removal of Pb, Cd and Zn from Heavily Contaminated Mine Tailing Soil Using Enhanced Electrochemical Process
- *Reena Amatya Shrestha* - The Petroleum Institute, The United Arab Emirates
- Nurcan Köleli and Aydeniz Demir - Mersin University, Turkey
- Sibel Pamukcu - Lehigh University, United States

10:15 – 10:30
Enhanced Electrokinetic Remediation of Cadmium-Contaminated Natural Clay by Phosphonates and EDTA
- *Ying-Ying Gu* - China University of Petroleum, China
- Albert Yeung - University of Hong Kong, Hong Kong

[2] All events will take place in the Egan Research Center unless otherwise noted (building #60 on the campus map at the end of this program.

- James Wang - Geosyntec Consultants, USA
- Charlotte Riis and Martin Bymose - NIRAS A/S, Denmark
- Mads Terkelsen - Denmark

13:30 – 13:45

Sustainability evaluation of electrokinetics and other remediation alternatives for a contaminated site: A case study

- *Krishna Reddy* - University of Illinois at Chicago, USA

13:45 – 14:00

A New Two-dimensional Laboratory Apparatus for Electrokinetic Extraction

- *Ying-Ying Gu* - China University of Petroleum, China
- Albert Yeung - University of Hong Kong, Hong Kong

14:00 – 14:15

Improvement of sludge electro-dewatering process using pretreatment techniques

- *Apostolos Giannis*, Jeremy Tan, Jing-Yuan Wang - Nanyang Technological University (NTU), Singapore

14:15 – 14:30

Electrokinetic flocs formation in municipal wastewater

- *Maria Elektorowicz* - Concordia University, Canada

14:30 – 14:45

Influence of the test set-up on Lithium migration in concrete

- *Lourdes M. S. Souza,* Rob B. Polder, Oğuzhan Çopuroğlu - TU Delft, The Netherlands

14:30 – 14:40 **Break**

14:40 - 16:40 **Poster Session (440 Egan Research Center)**

18:00 - 20:00 **Banquet (SkyWalk Observatory, Prudential Center, 800 Boylston Street)**

Tuesday June 25

7:45 – 8:30 **Continental Breakfast**

8:30 – 9:00 **Invited Presentation**

Nonlinear Electrokinetic Separations in Porous Media

Martin Z. Bazant, Massachusetts Institute of Technology, USA

9:00 – 10:15 **Session 3 – Fundamentals and modeling**

Session Chairs:

- Kitae Baek - Chonbuk National University, South Korea
- J.P.G. Gustav Loch - Utrecht University, The Netherlands

9:00 – 9:15

Electrochemistry and -kinetics in aqueous media containing amphoteric ions

- *Maarten Biesheuvel* - Wageningen University, The Netherlands

Poster List

#	Title	Presenter
1	Effect of pH control during electrokinetic bioremediation of a natural tropical soil	• *Maria Cláudia Barbosa*, Leonardo Deotti, Jonathan Tenório de Lima, Márcio de Souza Soares de Almeida - COPPE, Federal University of Rio de Janeiro, Brazil
2	Electrokinetic surfactant enhanced remediation of a tropical silty clay soil contaminated with crude oil	• *Maria Cláudia Barbosa*, Jonathan Lima, Márcio de Souza Soares de Almeida - COPPE, Federal University of Rio de Janeiro, Brazil
3	Electromagnetic Separation of Iron Nanoparticles Modeled by Adsorption	• *Henrik Hansen* - Federico Santa María Technical University, Chile
4	Electrodialytic remediation of phosphorus containing soils	• *Henrik Hansen* - Federico Santa María Technical University, Chile
5	Electromagnetic Separation of Iron Nanoparticles using a Coil as a Filter	• *Henrik Hansen*, Patricio Nuñez - Federico Santa María Technical University, Chile
6	Electrokinetic Remediation Combined with Reactive Barrier For As-Contaminated Soil	• *Eun-Ki Jeon*, Kitae Baek; Chonbuk National University, South Korea
7	Solar Cell-Based Electrokinetic Remediation of Heavy metal Contaminated Soil	• *Ji-Min Jung*, Kitae Baek; Chonbuk National University, South Korea
8	Electrokinetic Remediation for Removal of Alkali Metal Ions from Contaminated Soil by Tsunami	• *Yasuhiro Akemoto*, Masahiko Kan, Shunitz Tanaka - Hokkaido University, Japan
9	Electrokinetic removal of heavy metals from an agricultural soil	• *Claudio Cameselle*, Susana Gouveia - University of Vigo, Spain • Arylein Figerora, Henrik Hansen - Federico Santa María Technical University, Chile
10	Removal of heavy metals from an agricultural soil	• *Claudio Cameselle*, Susana Gouveia - University of Vigo, Spain • Arylein Figerora, Henrik Hansen - Federico Santa María Technical University, Chile
11	Interpretation of the titration and solubility curves of a soil contaminated by heavy metals using freeware chemical equilibrium speciation software	• *Cesar Gomez-Lahoz*, F. Garcia-Herruzo, Garcia-Rubio, M.D. Villen-Guzman - University of Málaga, Spain • J.M. Paz- García – Technical University of Denmark, Denmark
12	Alternative carbon materials for electrochemical remediation	• *Eric Gil*, Fernando Miguel de Amorim Lino, Muril Felisbino - Federal University of Goiás, Brazil
13	Simultaneous removal of fuel hydrocarbons and heavy metals from a railroad soil using electrokinetic remediation	• *Bo-Kyong Kim*, Jae-Young Lee, Tae-Soon Kwon, Woo-Hyun Chung - Korea Railroad Research Institute (KRRI), South Korea
14	EKR of copper mine residues with modified electric field	• *Adrián Rojo*, Henrik K. Hansen, Paula Inostroza - Federico Santa María Technical University, Chile

#	Title	Presenter
15	Electroabsorption of fluorine and chloride ions using carbon-impregnated TiO2 nanotube electrode	• *Xuhui Mao*, Yijia Yang - Wuhan University, China
16	Effects of Anodic O2 on Pd-catalytic Hydrodechlorination of Chlorinated Solvent in Groundwater Using Cathodic H2	• *Ali Ciblak*, Akram N. Alshawabkeh - Northeastern University, USA • Songhu Yuan - China University of Geosciences, China
17	Relationship microstructure-electrochemical behavior of alloys FeCoC	• *Mahrez Drir*, Farida Haddad, Sif Eddine Amara - University of Science and Technology Houari Boumediene (USTHB), Algeria
18	Ion transport in Nafion as studied by NMR	• *Leo Pel*, Shohreh Moshtari Khah, John van der Schaaf, Michiel van Soestbergen - Eindhoven Institute of Technology, The Netherlands
19	Study of the behavior of an acid-enhanced electrokinetic remediation performed with a real soil spiked with lead.	• *C. Gomez-Lahoz*, C. Vereda-Alonso, F. Garcia-Herruzo, J.M. Rodriguez-Maroto, M.D. Villen-Guzman - University of Málaga, Spain • M.A. Nekrasova, S. N. Sidorenko, K.A. Galkin, I.U. Pisar - Russian People's Friendship University of Moscow, Russia
20	Lab scale study of the influence of the acid strength over the performance of an acid-enhanced electrokinetic remediation	• *C. Gomez-Lahoz*, M.D. Villen-Guzman, R.A. Garcia-Delgado, F. Garcia-Herruzo, B. Arhoun, J.M. Rodriguez-Maroto - University of Málaga, Spain • J.M. Paz-Garcia - Technical University of Denmark, Denmark
21	Precipitation-Filtering Technology for Uranium Waste Solution Generated on Washing-Electrokinetic Decontamination	• *Gye-Nam Kim*, Seung-Soo Kim, Hye-Min Park, Won-Suk Kim, Uk-Rang Park, Jei-Kwon Park - Korea Atomic Energy Research Institute, South Korea
22	Response of indigenous microorganisms to bio-electrokinetics applied to remediation of soil contaminated with PAH and metals	• *Maria Elektorowicz* - Concordia University, Canada
23	Comparison on Environmental Footprints of Electrokinetic Remediation and Soil Washing	• *Bo-Ram Hwang*, Kitae Baek - Chonbuk National University, South Korea Do-Hyung Kim - Kumoh National Institute of Technology, South Korea
24	Effects of electrokinetic treatment of contaminated sludge on migration and transformation of cadmium, nickel and zinc based on chemical speciation	• *Jie Gao*, Qishi Luo, Changbo Zhang, Bingzhi Li, Yue Zhu; Shanghai Academy of Environmental Sciences, China
25	Reducing the hydroxyl ion penetration in sediment during electroremediation	• *Ljiljana Rajić*, Božo Dalmacija, Svetlana Ugarčina Perović, Srđan Rončević, Vira Karlović, Đurđa Kerkez, Snežana Maletić - University of Novi Sad, Serbia
26	Electrokinetic removal of Cr, Cu and Zn from sediment by pulsed electric field	• *Ljiljana Rajić*, Božo Dalmacija, Dejan Krčmar, Milena Bečelić-Tomin, Svetlana Ugarčina Perović, Vesna Pešić, Malcolm Watson - University of Novi Sad, Serbia

#	Title	Presenter
27	Estimation on the remediation cost of in-situ electrokinetic process for multi-metal contaminated site	• *Jae-Cheol Lee*, Kitae Baek - Chonbuk National University, South Korea • Do-Hyung Kim - Kumoh National Institute of Technology, South Korea
28	Modeling of electrodialytic removal of phosphorous from soil	• *Juan Manuel Paz- García* - Technical University of Denmark, Denmark • Claudia Gutierrez-Cordova, Henrik K. Hansen, Alejandro Arce Torres - Federico Santa María Technical University, Chile • Margarida Ribau Teixeira, Luis Nunes, Nuria Salvador - University of the Algarve, Portugal • Jose Miguel Rodriguez Maroto - University of Málaga, Spain
29	Electro-osmotic transport of nano zero-valent iron in Boom Clay: nZVI distribution and effect in the clay	• *Celia Dias-Ferreira* - CERNAS, Agrarian School of Coimbra, Portugal • J.P. Gustav Loch and Pieter J. Kleingeld - University of Utrecht, The Netherlands • Emilio Rosales - CERNAS, Agrarian School of Coimbra, Portugal and University of Utrecht, The Netherlands
30	Reactive transport modeling. Coupling chemical kinetics and chemical equilibrium in electrokinetic phenomena	• *Juan Manuel Paz-García*, Lisbeth M. Ottosen, Björn Johannesson - Technical University of Denmark, USA • María D. Villén-Guzmán and José M. Rodriguez-Maroto - University of Malaga, Spain
31	Modeling of transport processes through ion exchange membranes	• *Juan Manuel Paz-García*, Lisbeth M. Ottosen - Technical University of Denmark, Denmark • Oscar A. Prado-Rubio - LiqTech International A/S, Denmark • María D. Villen-Guzman and José M. Rodriguez-Maroto - University of Málaga, Spain
32	Potential of electrokinetic process to upgrade an antimony and arsenic contaminated soil - Suitability of coupled technologies	• *Nazaré Couto and Paula Guedes* - CENSE, New University of Lisboa, Portugal and Chinese Academy of Sciences, China • Yujun Wang - Chinese Academy of Sciences, China • Alexandra B. Ribeiro - CENSE, New University of Lisboa, Portugal • Dong-Mei Zhou - Chinese Academy of Sciences, China
33	Electrodialytic remediation of incinerated sewage sludge - Influence of natural weathering	• *Alexandra B. Ribeiro* - University of Lisboa, Portugal • Paula Guedes, Nazaré Couto – CENSE, New University of Lisboa, Portugal and Technical University of Denmark, Denmark • Lisbeth M. Ottosen - Technical University of Denmark, Denmark.
34	Assessing the feasibility of the EKR of soils contaminated by heavy metals by titration curves	• *Carlos Vereda-Alonso*, R.A. Garcia-Delgado, B. Arhoun, M.D. Villen-Guzman - University of Málaga, Spain • J.M. Paz- García - Technical University of Denmark, Denmark
35	Comparing the effect of electrodialytic upgrading on semidry, dry and wet air pollution control residues	• *Lisbeth M. Ottosen*, Pernille E. Jensen, Gunvor M. Kirkelund - Technical University of Denmark, Denmark
36	Electrodialytic decontamination of fly ash from small scale waste incinerators in Greenland	• *Lisbeth M. Ottosen*, Gunvor Marie Kirkelund, Pernille E. Jensen - Technical University of Denmark, Denmark
37	Using of electrochemistry in the study of FeVTiC alloys	• *Leïla Amara-Adnane*, Assia Aouiz, Rafika Kesri - University of Science and Technology Houari Boumediene (USTHB), Algeria

ATTENDEE LIST

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POSTER ABSTRACTS

(1) Effect of pH control during electrokinetic bioremediation of a natural tropical soil

Maria Cláudia Barbosa, Leonardo Deotti, Jonathan Tenório de Lima, Márcio de Souza Soares de Almeida - COPPE, Federal University of Rio de Janeiro, Brazil

Electrokinetic remediation is an emerging technique for in situ treatment of contaminated soils. Applications coupled with bioremediation intend to inject nutrients in the soil to enhance contaminant degradation by microbial activity. However in some cases bacterial growth is reduced whereas pH gradients develop within the soil and compounds may precipitate on cathode due to its pH higher than 11. This work presents the results of pH control on soil properties and bacterial development during electrokinetic bioremediation of a clayey soil formed from a limestone matrix contaminated with hydrocarbon. The survey is based on 1D laboratory scale tests applying a total potential difference of 10 V during 48 h. Two different solutions were used: (1) a buffer solution of di-sodium hydrogen phosphate (Na2HPO4) and potassium hydrogen phosphate (KH2PO4) and (2) a solution of sodium chloride. The inversion of the EK field during the test was also applied as a third alternative for pH control. A few arrangements were elaborated for every experiment set up varying boundary and initial conditions. The goal for pH control was to prevent soil acidification in the anode vicinity, which has a negative impact on bacterial population. For this purpose anode and cathode reservoirs were filled with a saline solution with a known pH. Results demonstrated that bacterial population decrease was minimized under pH control. Electrodes degradation was also prevented and nutrient injection succeeded for most nutrients. It was observed that phosphate was rapidly precipitated close to the electrodes. Electric potential was lower in experiments with pH control when compared to a standard experiment. Electric field varied from 0.2 to 0.4 V/cm and upper values are related to more saline solutions. The laboratory tests showed that pH control may improve soil treatment but field tests are still necessary.

(2) Electrokinetic surfactant enhanced remediation of a tropical silty clay soil contaminated with crude oil

Maria Cláudia Barbosa, Jonathan Lima, Márcio de Souza Soares de Almeida - COPPE, Federal University of Rio de Janeiro, Brazil

Electrokinetic remediation is being used for fine low-permeability heterogeneous and anisotropic contaminated soils treatment especially clays. Several studies have demonstrated its feasibility in laboratory and in situ applications for different contaminants mainly heavy metals. Recently it has also been employed for soils contaminated with NAPLs which are rather hydrophobic than hydrophilic and thus surfactants can be used together with more traditional techniques to aid removal. Surfactants have unique characteristics which increase the solubility of organic compounds and their further mobility and extraction. This work presents the results of an attempt to enhance electroremediation of PAHs with sodium dodecyl sulfate. Soil samples were collected from Sarapuí river (Rio de Janeiro/Brazil) and artificially contaminated with crude oil to 10g/kg of dry soil. The samples have an average specific gravity of 2.01 g/cm^3, 8.1% of organic matter content and a total cation exchange capacity of 32.38 cmolc/kg. It can classified as a silty clay. Two different laboratory experiments arrangements were fulfilled. For every sample it was applied a 10V total electric

(19) Study of the behavior of an acid-enhanced electrokinetic remediation performed with a real soil spiked with lead

C. Gomez-Lahoz, C. Vereda-Alonso, F. García-Herruzo, J.M. Rodriguez-Maroto, M.D. Villen-Guzman - University of Málaga, Spain
M.A. Nekrasova, S. N. Sidorenko, K.A. Galkin, I.U. Pisar - Russian People's Friendship University of Moscow, Russia

Since the 1980s decade there has been a sharp increase in the research for the development of new techniques for the remediation of contaminates sites, because one after another country realized that the economic budget that would require the recovery of all these sites is simply unaffordable. Most countries have developed criteria to prioritize the remediation of those sites that were bearing the most severe risks for humans or the environment. Also an important effort has been done in order to make available new techniques more economic.

Regarding both, the risk assessment and the development of new techniques, the most typical research approaches at the lab-scale are either the use of an already contaminated soil or the use of a model soil in which the contaminant is spiked. In the first case, the complexity of the soil matrix makes the derivation of conclusions applicable to other soils quite difficult. In the second case, the simplicity of the soil matrix can make the results more reproducible at different labs, but may be also of limited interest for the real contaminated soils, since that simplicity will be found in very few real cases.

Furthermore, the contact time between the contaminants and the real contaminated soils is usually larger than several months and can even be in the order of centuries. Obviously this contact time may not be used in the experiments at the lab scale. In these cases, typically, in the most favorable case, a series of experiments of different contact time are carried out, which range from some minutes or few hours to several days or even weeks. Then a comparison is made from which the conclusion is usually that a contact time of several hours or few days is large enough to assure that the different equilibria are reached. Nevertheless, it is also widely known that the transport of contaminants through the soil matrix can be very slow. Also that it can be difficult to distinguish between the pseudo-steady states that can control the partitioning between different soil compartments and the real thermodynamic partitioning.

Thus, there is a clear lack of experimental results obtained for soils that are spiked with a certain contaminant and allowed a variable contact time (ageing) ranging from weeks to years. In this work we present the first results that we have obtained for a soil that presents a moderate background concentration of lead, and was spiked with an additional amount of lead nitrate. The mobility of lead is studied by the BCR sequential extraction procedure, which divides the lead concentration into three fractions (weak acid soluble, reducible and oxidizable), besides the residual fraction that is obtained to investigate the mass balance, and support the quality of the analysis. It has been shown in the literature that the BCR fractionation can be used, together with mathematical models, to do reliable predictions about the maximum removal yield that can be obtained from several remediation techniques, including the electrokinetic remediation. In this paper we present the results of an early stage of the ageing process. The electrokinetic experiment is performed in a duplicated lab column assay using a constant current density and the disposition of the two columns electrically in series, to allow the maximum reproducibility of the results.

Acknowledgements

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