GEOELECTRICAL METHODS APPLIED ON A CONTAMINATED SITE : THE ENTRESSEN LANDFILL CASE STUDY (SOUTH-EASTERN FRANCE)

Véronique NAUDET*, André REVIL, Jean-Yves BOTTERO

UMR CNRS 6635, CEREGE B.P.80, Europôle Méditerranéen de l'Arbois, 13545 Aix-en-Provence Cedex 04, France

*e-mail: naudet@cerege.fr Tel. : +33.(0)4.42.97.17.82 fax : +33.(0)4.42.97.17.85 http://www.cerege.fr

1. Introduction

The redox potential is a controlling parameter in many sites remediation technologies. However, it is hard to obtain reliable and representative values of this parameter from geochemical measurements. Recent geo-electrical field studies carried out over organic waste dumps show negative self-potential (SP) anomalies [3] [5]. These SP anomalies seem to be due to redox reactions occurring at depth during biodegradation. We perform a large SP field study over the Entressen landfill (France). The results suggest that the SP method could open the door to the determination of redox potential from SP data inversion.

2. The SP method

SP : passive measurements performed at the ground surface of natural electric field occurring at depth.

Main sources :
1) *electrokinetic effect* associated with the groundwater flow through the porous media,
2) *redox effect* associated with the biodegration of organic matter in contaminant plumes.

Signal :
1) *positive* anomalies in the groundwater flow direction,
2) *negative* anomalies in the contaminated area.

Theory :
1) underlying physics fairly well established [4],
2) no theoretical model established in the case of contaminant plumes.

3. Field study

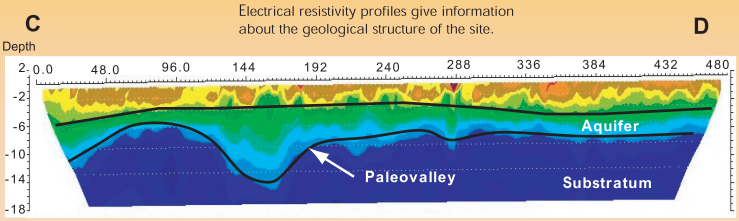
The Entressen landfill

Characteristics : the biggest open-air landfill in France (0.5 km² and 30 m height) with about 600.000 tons per year of municipal and domestic wastes stored since 1912.

Geochemistry : about ten available piezometers show that the contaminant plume extents to a maximum of 4.6 km away from the landfill, with a redox front located near the piezometer 6 [6].

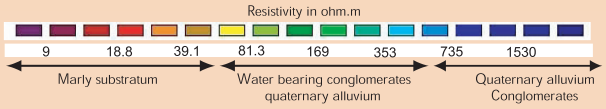
4. Results

Electrical resistivity profiles give information about the geological structure of the site.



Iteration 5 RMS, error 2.7 %

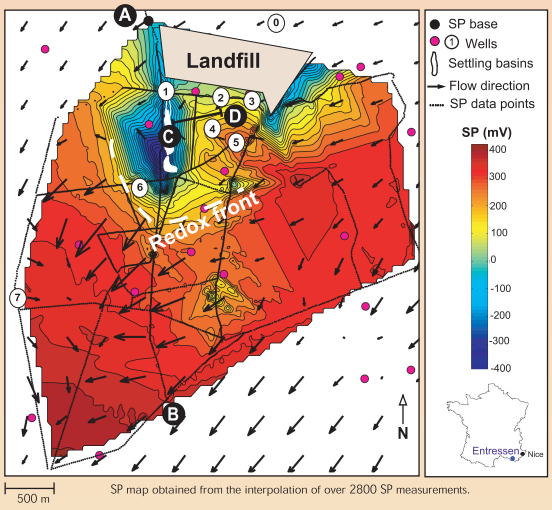
Unit electrode spacing 3.0 m



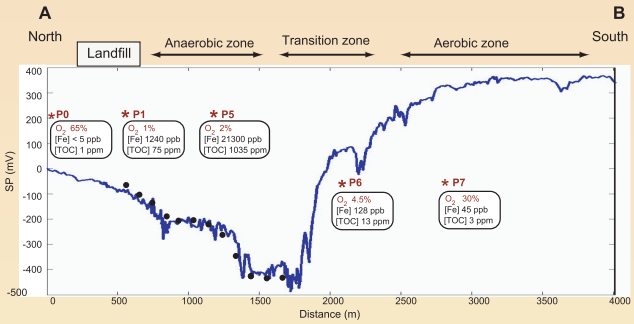
The SP map shows a strong negative anomaly of -400 mV located near the settling basins. This suggests a leakage of the basins.

The AB profile shows that the SP-signal is correlated with the variation of the pore water chemistry. The SP progressively decreases in the anaerobic zone, and drastically increases in the transition zone.

The negative SP anomaly seems to mimic the redox zone of the contaminant plume.



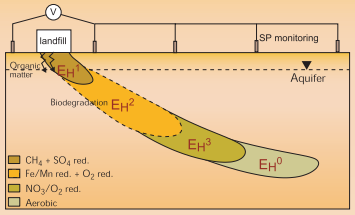
SP map obtained from the interpolation of over 2800 SP measurements.



5. Discussion

The thermodynamic source of the SP seems to correspond to a redox potential gradient. The transfer of charge between the different redox zones is either due to ionic species diffusion or electro-migration of electron through biofilms.

The redox potential seems to play a role similar to the hydraulic charge in the hydroelectric coupling problem.



Development of redox zones in a contaminant plume

We propose that the source current density *js* due to redox effect is :

$$\vec{j}s = \sigma \vec{\nabla} (C_{ox} E_H)$$

with C_{ox} a sensitivity coefficient
φ the electrical potential,
E_H the redox potential and
σ the electrical conductivity

C_{ox} could be obtained in the field through a correlation between a couple of in situ redox potential measurements and the local value of SP.

6. Conclusions

This SP field study suggests that the main source of the SP-signal is associated with a transfer of charge due to either various ionic species diffusion or electron migration through biofilms. Additional research works need to be carried out to understand the physics of this coupling (simulation in a sediment-filled tank). When the model of such a geobattery would be established, inverse algorithm could be used to determine the redox potential distribution from SP-signals.

References

[1] - Bond, D. R. ,D. E. Holmes, L. M. Tender, and D. R. Lovley, Electrode-reducing microorganisms that harvest energy from marine sediments, Science, 295, 483-485, 2002.
[2] - Christensen T. H., P. L. Bjerg, S. A. Banwart, R. Jakobsen, G. Heron, and H.-J. Albrechtsen, Characterization of redox conditions in groundwater contaminant plumes. *Journal of Contaminant Hydrology*, 45, 165-241, 2000.
[3] - Nyquist J. E., and C. E. Corry, Self-potential: the ugly duckling of environmental geophysics, *The leading edge 21*, 5, 446-451, 2002.
[4] - Revil A., D. Hermitte, M. Voltz, R. Moussa, J.-G. Lacas, G. Bourrié, and F. Trolard, Self-potential signals associated with variations of the hydraulic head during an infiltration experiment, *Geophysical Resource Letter*, 29, 10.1029/2001 GL014294, 2002.
[5] - Vichabian Y., P. Reppert, and F. D. Morgan, Self potential mapping of contaminants, *Proceedings of the Symposium on the application of geophysicsto engineering and environmental problems*, March 14-18, SAGEEP, 1999.
[6] - Vilomet J.-D., B. Angeletti, S. Moustier, J.-P. Ambrosi, M. Wiesner, J.-Y. Bottero, L. Chatelet-Snidaro, Application of strontium isotopes for tracing landfill leachate plumes in groundwater, *Environmental Science & Technology*, 35, 23, 4675-4679, 2001.

Poster conception, drawing and printed by "Groupe Dessin", CEREGE, BP80, Europôle Méditerranen de l'Arbois, 13545 Aix-en-Provence Cedex 04 - France