SOIL CONTAMINATION PROCESS DURING LEACHATE INFILTRATION

Laouni GAIDI[1,2], Chahira SAYAD[1], L. BENADELA[1] and B. BENYAMINA[1]
[1]Laboratoire LSTE, Université de Mascara, Algérie
[2]Email : lgaidi@yahoo.fr, laouni.gaidi@univ-mascara.dz

ABSTRACT
To carry out the pollutant transfer mode in unsaturated soil and pollutant action onto the soil, infiltration and standard laboratory hydraulic conductivity tests were performed on soil column. During infiltration tests, soil moisture and soil electrical conductivity were measured to observe moisture and leachate solute movement. Infiltration curves were used to describe leachate inflow and the steady infiltration rate. Moisture profiles allowed the observation of the soil saturation process and the determination of the leachate transit time in the soil column. Soil electrical conductivity profiles give the pollutant distribution in the soil column.
Studies have shown that the hydraulic conductivity of compacted soil permeated with leachate can be significantly higher than the hydraulic conductivity of the same soil permeated with water (Gleason et al. 1997). Laboratory permeability tests performed with different water head, carry out the influence of the leachate and the hydraulic gradient on the soil hydraulic conductivity.

Keywords: soil, leachate, permeability, TDR method, profiles

MATERIALS AND METHOD

Pollution tests were performed with leachates produced by leaching waste clinker, lead slag and REFIOM. The percolation of these leachates through soil layer, was compared to water percolation. To achieve test results in a reasonable time, soil used must have a hydraulic conductivity close to 10^{-7} m/s after compaction.

Devices and Experimental procedure

For different tests, the dry soil was wetted at optimum water content (w_{opt} = 10%) and compacted to achieve a dry unit weight of 16kN/m^3. During infiltration tests, moisture movement was monitored with TDR probes. Soil water content and electrical conductivity were assessed by TDR pulse analysis.

TDR Method

Measuring the transit time and the amplitude of an electromagnetic pulse which propagated along a transmission line embedded in soil, soil dielectric constant and voltage reflection coefficient can be calculated. Topp et al.(1991) proposed the following relationship to determine the soil volumetric water content when the soil dielectric constant is known :

$$\theta = -0.053 + 0.29K_a - 5.5\ 10^{-4}K_a^2 + 4.3\ 10^{-6}K_a^3,$$

where K_a dielectric constant and θ volumetric water content

To improve volumetric water content determination, TDR probe was calibrated with the different leachates used for infiltration tests. The three used leachates have different pH, different electrical conductivity and different solute concentration. Chemical characteristics of these leachates are shown in table 1.
Dry soil wetted at known water content is compacted in a ring equipped with a three rod TDR probe. Soil dielectric constant versus soil volumetric water content is evaluated with TDR curves. The calibration function of volumetric water content versus dielectric constant for soil used in infiltration tests is computed for the three leachates and water.

Table 1 Leachates chemical characteristics

Leachate	pH	Electrical	Redox potential	Solute concentration

		conductivity (mS/cm)	(mV(ENH)	(mg/l)
Waste clinker	7.9	12.63	317	7996
Lead slag	6.3	53.3	298	75446
REFIOM	7.6	11.2	312	6980

Infiltration Test Device

The infiltration tests are carried out in PEHD column having 550mm in length, composed with rings of 50mm height and 106mm of diameter. The soil was wetted at desired water content and compacted at desired bulk density in each ring. Before soil compaction, five rings were equipped with three rod TDR probe of 80mm length. After the setting of the column, TDR probes are located at 75, 175, 275, 375, 475mm depth. The column is installed as it is shown in figure 1.

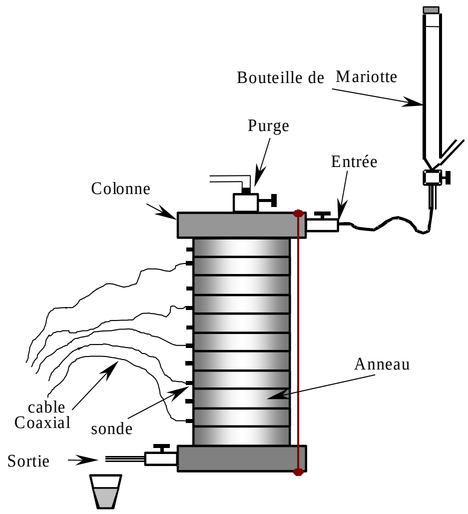


Figure 1 Schematic of soil column used for infiltration tests

RESULTS AND DISCUSSION

Experimental results concerned infiltration curves, moisture and bulk electrical conductivity distribution and the trends in the soil permeability coefficient. The use of different leachates must reveal the leachate action on the soil. Choice of the soil permeability equals to 10^{-7} m/s allows liquid to outflow after one or two days. Moisture profile analysis must show the soil saturation degree when the liquid outflow starts. Soil bulk electrical conductivity profiles associated to water content profiles allow the comparison of moisture and solute migration.

Soil permeability results

Standard laboratory hydraulic conductivity tests were performed with three water head pressure, 20, 50 and 100cm. Before permeability test, each sample is saturated under water head pressure equals to 50cm. Test results are represented by the average liquid flux q ($m^3/s/m^2$) versus hydraulic gradient i = dh/dL.

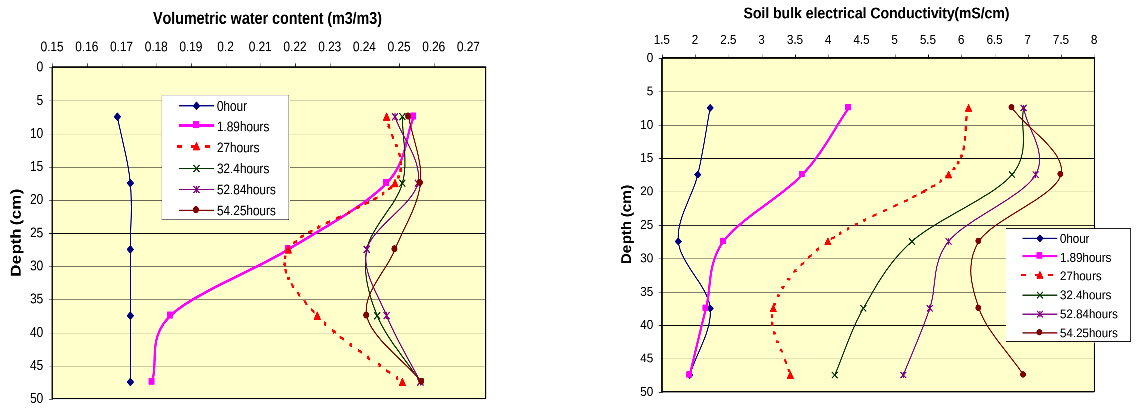
It is shown in table 2 the average value computed with all measured data during the permeability tests, regardless of hydraulic gradient influence. It is noticed that the hydraulic conductivity hardly does not change, when the soil is permeated by water, waste clinker leachate or lead slag leachate. It becomes ten time higher when the soil is permeated by REFIOM leachate.

Table 2 Average hydraulic conductivity k for water and leachates

	water	waste clinker leachate	lead slag leachate	REFIOM leachate
k (m/s)	1.64 10^{-7}	1.43 10^{-7}	1.46 10^{-7}	1.61 10^{-6}

Moisture and Electrical Conductivity Profiles

Figures 2 and 3 present moisture profiles and bulk electrical conductivity profiles in the column during the permeation of waste clinker and lead slag leachates. Soil bulk electrical conductivity is determined with TDR curve, using the method described by Nader et al (1991) and Alimi (1998).



(a) **(b)**

Figure 2 Moisture and bulk electrical conductivity during waste clinker leachate infiltration

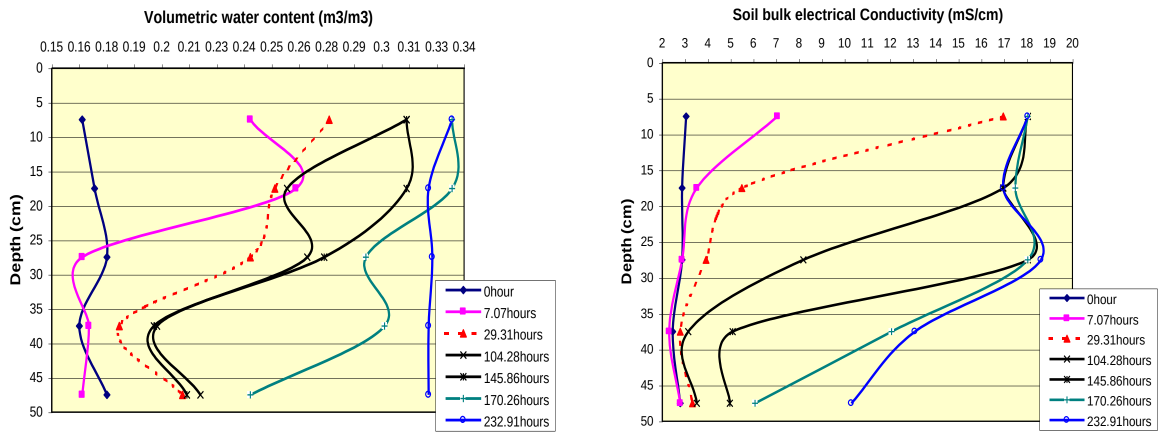


Figure 3 Moisture and bulk electrical conductivity during lead slag leachate infiltration

Profiles represented by dash line are the profiles when the leachates outflow the column. Leachate transit times in the soil column are 27 and 29 hours respectively for waste clinker leachate and lead slag leachate. The transit time is not really affected by the leachate quality but it is half time less than water transit time (52 hours) in the soil column. At the transit time, moisture is not uniform in the soil column but the reached saturation degree is higher in column infiltrated with waste clinker leachate than in column infiltrated with lead slag leachate. The leachate action on the soil depends on the leachate characteristic. It is noticed also that soil saturation with leachate continues during the outflow. The leachate flows through the soil column before water content becomes uniform in the soil.

The bulk electrical conductivity profiles shown in figures 2 (b) and 3 (b), prove that, the upper layers retain more solute than the lower layer before leachate outflows the soil column. During the waste clinker percolation, pollutant retaining remains more important in upper layer although the water content along the soil column becomes uniform. The soil purifies the percolated leachate.

When the lead slag leachate percolates throughout the soil column, the column upper layer becomes saturated with solute before a uniform water content was obtained along the column. This upper part saturated with solute remains saturated when the uniform water content is reached along the column. The interaction between soil and lead slag leachate is more important than that of waste clinker leachate.

It is shown with these profiles that the soil volumetric water content does not exceed respectively, 26% and 33% when waste clinker and lead slag leachates are percolating. These water content values represent respectively 66% and 85% of the porosity of the soil compacted at the bulk density γ_d/γ_w equal to 1.6. The soil porosity occupied during water percolation reaches 92%.

CONCLUSION

This study allows the evaluation of the soil pollution process. It is shown that the solute action on the soil can be described by the transit time, that to say the time for the leachate to percolate unsaturated soil. The reduction of this time for the leachate percolation means that liner layer thickness must be increased to prevent rapid percolation and to secure ground water.

This leachate action is also described by the soil hydraulic conductivity. Standard permeability tests show that the soil permeability coefficient can increase ten times when it is percolated by leachate. This result proves that the liner must be tested with leachate to determine its permeability and to project its thickness.

The use of TDR probes during infiltration tests allows to observe that the soil is not saturated before water or leachates flows out of the column. When uniform water content is reached in the column, the saturation degree remains less than 95% as it is recommended in hydraulic conductivity test.

REFERENCES

ALIMI ICHOLA I., (1998) Use of Time Domain Reflectrometry Probes for monitoring unsaturated soil pollution Proc. of 3rd Int. Cong. On Environmental Geotechnics, Lisboa,Portugal 7-11 Sept. 1998 pp. 107-112

GLEASON, M. H., DANIEL, D. E., and EYKHOLT, G. R. (1997) Calcium and Sodium Bentonite for Hydraulic Containment Applications, Journal of Geotechnical Environmental Engineering, ASCE, Vol. 123, No 5, pp. 438-445.

TOPP, G. C., DAVIS J. L. and ANNAN, A. P. (1980) Electromagnetic Determination of Soil Water Content : Measurement in Coaxial Transmission Lines. Water Resour. Res. 16 : 574-582