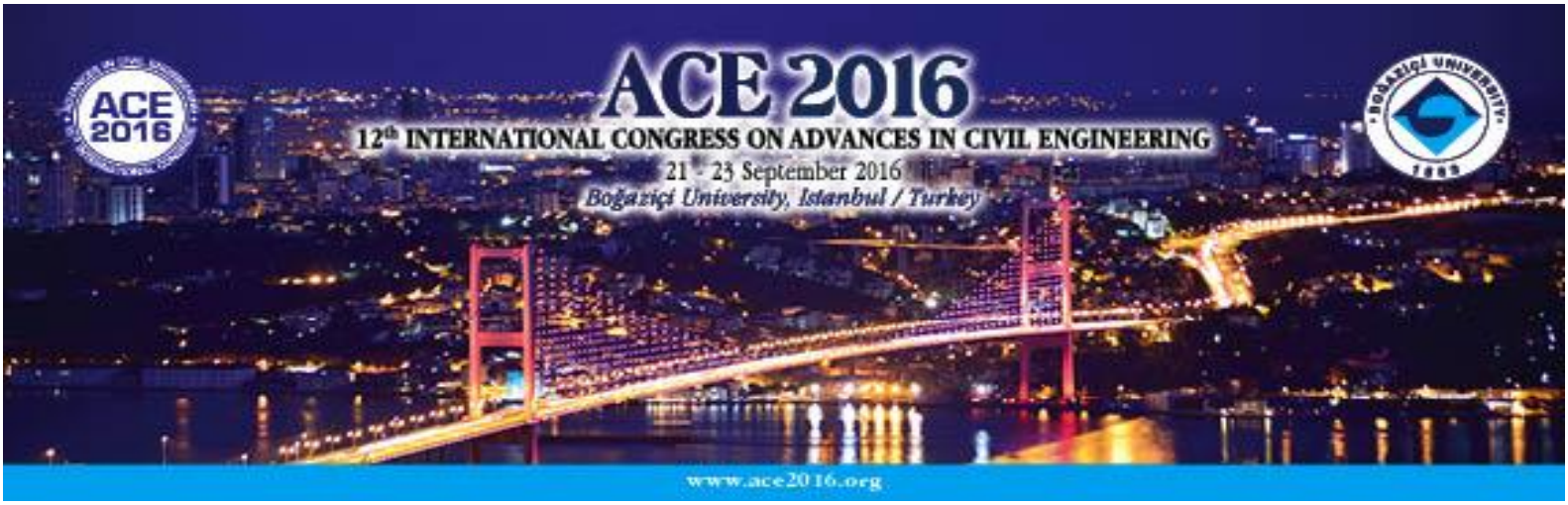

Study of the effectiveness of waterproof barriers against the risk of infiltration of sludge pressings in landfills

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Abstract

The subject of this study is setting in the preservation of the environment. It focuses on the study of the pollution of soil and water resources by infiltration.
The controlled landfill is a geotechnical process considered a waste disposal method. For these active and passive water barriers, the permeability of which is less than 10^{-9} m/s, the landfill is limited disorders that can cause water circulation, and completely block its waters.
This study aims to identify and evaluate the degree of toxicity of a pollutant (sludge pressing) on the ground, to arrive at a sound management by adequate technical and economically sustainable.
In order to achieve an optimum blend, ensuring a good performance in terms of the hydraulic conductivity, mixtures of sand with different concentrations of bentonite, to the compact state, are prepared and studied.
This study showed that a low permeability of mixture (sand/bentonite) can be obtained with the introduction of 8% of bentonite. Therefore, it represents an optimum blend for sealing systems, because of its economic and ecological advantages.
Comparison of laboratory results, after treatment and analysis, to norms in vigor's will determine that, for a coefficient of permeability of the order of 10^{-10} m/s, the contaminant infiltrates into the soil and water becomes polluted. It is not recommended to throw it kind of pollutant in controlled landfill; but it is best to think of appropriate collections of operations and treatment in specialized factories.

Keywords: *Landfill, infiltration, permeability, bentonite, sludge pressings.*

1 Introduction

In the domain of waste management, many countries have developed different types of approaches to provide a set of solutions adaptable to their investment and management capabilities. The diversification of waste treatment techniques leads to sometimes complex choices. Each treatment modality has advantages and disadvantages, and there is no panacea. It is necessary to determine the mode of treatment most suited to local socio-economic context. (ADEME, 2005)
In Algeria, the different types of waste products currently are, in nearly their almost all, spread over some 3,000 illegal dumps occupying about 150,000 hectares. (METAP, 2004)
Faced with the critical state of the environment, public authorities have developed a National Environmental Strategy (NES), involving the development of effective public policies, strengthening the legal and regulatory framework (Law No. 01-19 of December 12, 2001) (JORADP, 2001) sustainable management of natural resources and improving the living environment of citizens (National Fund for the Environment and pollution control). (MATE, 2003)
The landfill, or technical landfill, is a geotechnical process considered as a waste disposal method. For these active and passive waterproof barriers, the permeability of which is less than 10^{-9} m/s, the landfill can limited disorders that can cause water circulation, and completely block its waters. (MATE, 2005)
In our days, the use of bentonitic geosynthetic for soil sealing is one of the most used in whole world. Many researchers have been conducted on the hydraulic performance of bentonite (BENTAL-ENOF, 2010) (Didier and Cavalcante Rocha, 1998) (Gleason, et al., 1997) (Gueddouda et al., 2008) (Komine, 2004).
Although, initially, the hydraulic properties entering in the standards for waste storage center, the problem raised is that the effectiveness of waterproof barriers in the presence of liquid charged with contaminating elements. It is in this context that our research fits. It is dedicated to the establishment of the link between geotechnics and the environment; he has for aims to test the infiltration of a pollutant (sludge pressings) for a compacted mixture of treated sand with bentonite.

2 Principles and objectives

In Algeria, according to our survey of land, waste cleaners, always remains disposed of with household waste or down the sewers.
The basic principle adopted in this study is that "one of the conditions to be fulfilled by waterproof barriers in Class 1 of landfill site is to ensure a permeability coefficient less than 10^{-9} m / s."
In this context, the objective of the tests performed in this work is the search to justify the admissibility landfill class 1 of sludge of dry cleaners.
For this two companions of tests were carried out:

- ✓ The first mate consists to research - Using two local deposits - a coefficient of permeability of the order of 10^{-10} m /s, by permeability tests on a compacted mixture of sand and bentonite with different percentages of the latter.
- ✓ Secondly, we completed this study with a series of infiltration tests of a pollutant realized on selected samples.

3 Methodology

We present the results of the identification work of two local materials: sand of Baghlia (Boumerdes) and bentonite of Mostaganem. This characterization consisted of a physico-chemical and mineralogical study. In effect, several tests were conducted; among which the particle size by laser beams, the cation exchange capacity, the diffractometer by the laser beam and scanning electron microscope.
After studying the evolution in the permeability of a compacted mixture of sand and bentonite, at different percentages of the bentonite, it will focus on the analysis of the infiltrated water, essentially for the sample constituted of 8% of bentonite when subjected to a pollutant.
We are completing our research by a general conclusion that summarizes the essence of our work.

3.1 Identification of materials

3.1.1 Characteristics of sand

The sand used comes from the quarry of Sidi Daoud, Baghlia town, located 40km to the west of the city of Tizi Ouzou. The characteristics are grouped as following:

Table 1. The characteristics of sand.

Equivalent of sand (E_S)	Uniformity Coefficient (Cu)	Gradation Coefficient (Cc)
100%	3	1.33

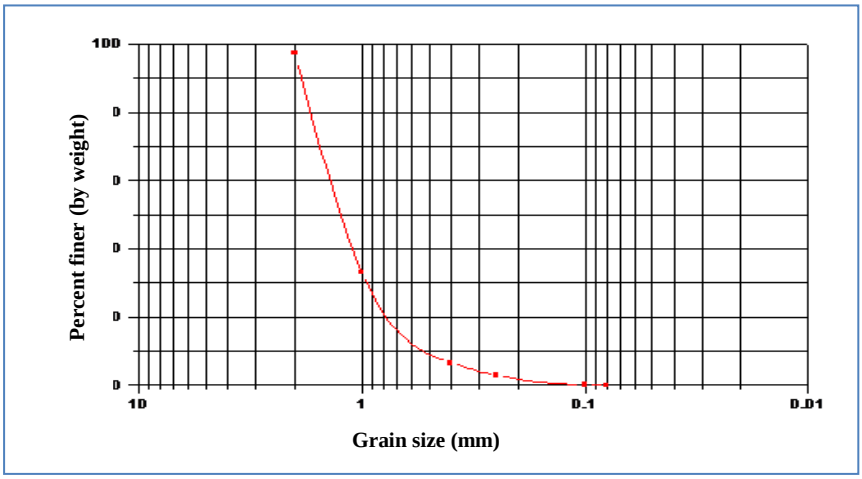

Figure 1. Particle size distribution curve of sand.

3.1.2 Characteristics of the bentonite

Different identification tests show that our bentonite contains more than 70% of less than 2µm elements.
The diffractometer showed the presence of montmorillonite with illite associated with impurities such as quartz and feldspar (Fig.2). Natural water content in the marketing status not more than 9%. At tap water, the liquid limit and the plasticity index are respectively 238% and 194%. A free swelling of 23ml.
The specific surface given by the test with methylene blue (spot test) is estimated to be an average value of 66.85 m^2/g. The cation exchange capacity is 43 meq/100g (Debieche, 2007).
The chemical composition of bentonite tested by fluorescence X-ray contains test in addition to free quartz, calcium content greater than that of sodium.
In light of the data collected, we can conclude that the bentonite Mostaganem is an active calcium montmorillonite and has a relatively large water absorption potential, thus giving it the possibility of use in reducing the permeability.

3.1.3 Sludge pressings

Cleaning clothing is made with machines in closed circuit according to NFG 45-011standard. At the final drying stage, the area charged solvent is not more advanced toward the outer but it is recovered by passing through activated carbon (INERIS, 2005).
Despite good conditions for recycling and efficient drying system distillation residues, a significant proportion of these residues remain in Perchlorethylene containing lint and dirt clothing; this is the so called sludge.
Perchloroethylene (Tab.2) is a chlorinated solvent, mainly used as a degreaser in Dry cleaning metals, skins tannery, textiles and electronics. It is also used as a heat transfer fluid, insecticides, rat poison, anthelmintic and for the cleaning of septic tanks.
Perchlorethylene is dangerous to humans and the environment (toxic to the nervous system, kidneys, aquatic organisms ...) (Dutheil, 2003).

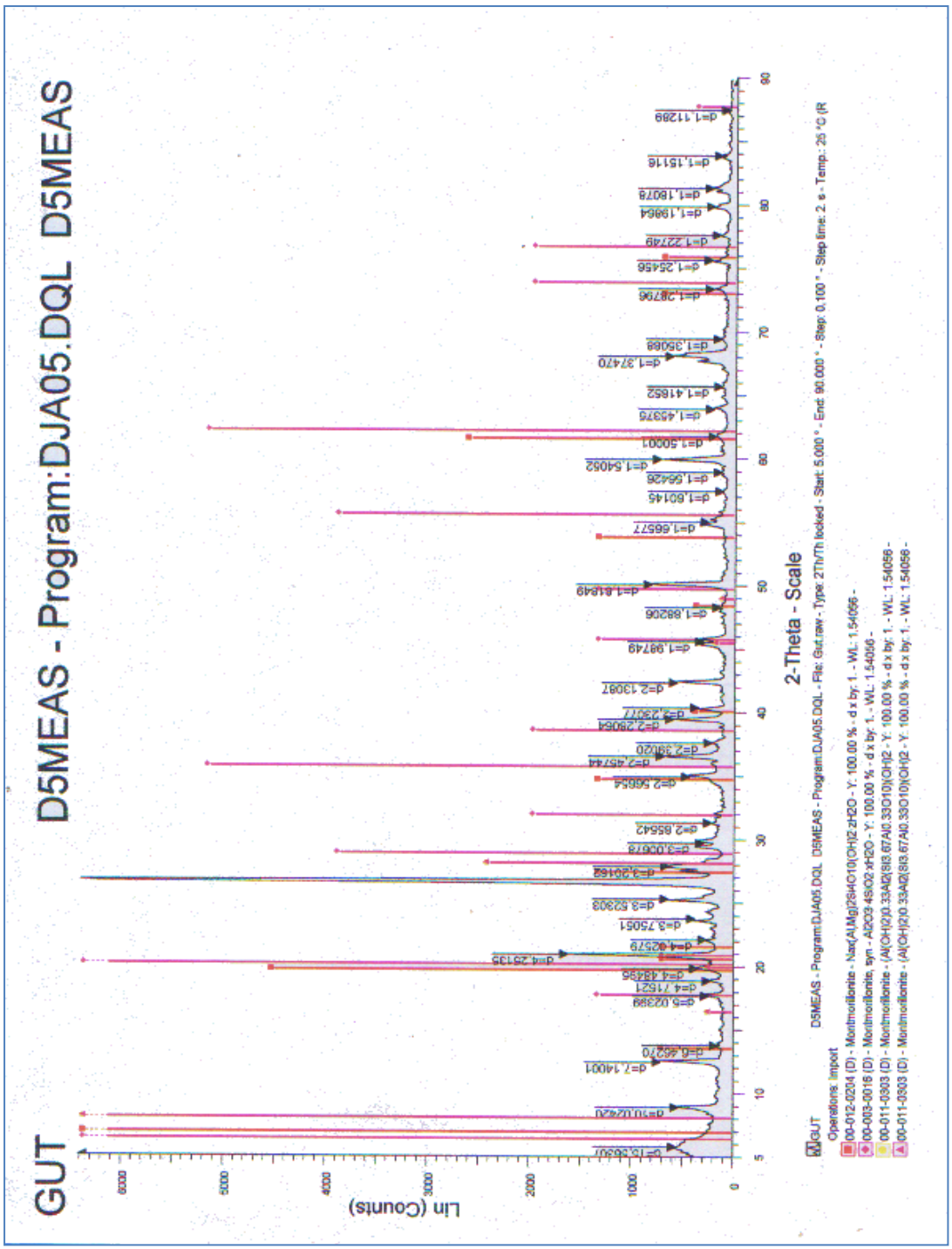

Figure 2. X-ray diffraction patterns of a sample which consists of compacted mixture of 92% sand and 8% of bentonite.

Table 2. Main physicochemical characteristics of Tetrachloroethylene. (Jules, 2004)

Formula	C_2Cl_4
Molar mass (g/mol)	165,83
Solubility in water à (g/L)	0,15 (25° C)
Density (g/cm3)	1,613
Boiling point (°C)	121,1
Vapor pressure (mm Hg)	14 mmHg (20°C)
Viscosity	0.89 cP at 25 °C

3.2 Permeability tests

3.2.1 Compaction of the samples

Compaction optimum Proctor tests were carried out for the percentages of 0%, 4%, 6% and 8% of bentonite. The figure. 3 shows the superposition of different Proctor curves.
The optimal values of the water content and dry weight volume are shown in the table 3.

Table 3. Values of W_{opt} et γ_{dopt}.

% bentonite	w_{opt} (%)	γ_{dopt} (kN/m^3)
0%	12.0	16,25
4%	13.9	17.15
6%	14.6	17.70
8%	15.3	17.65

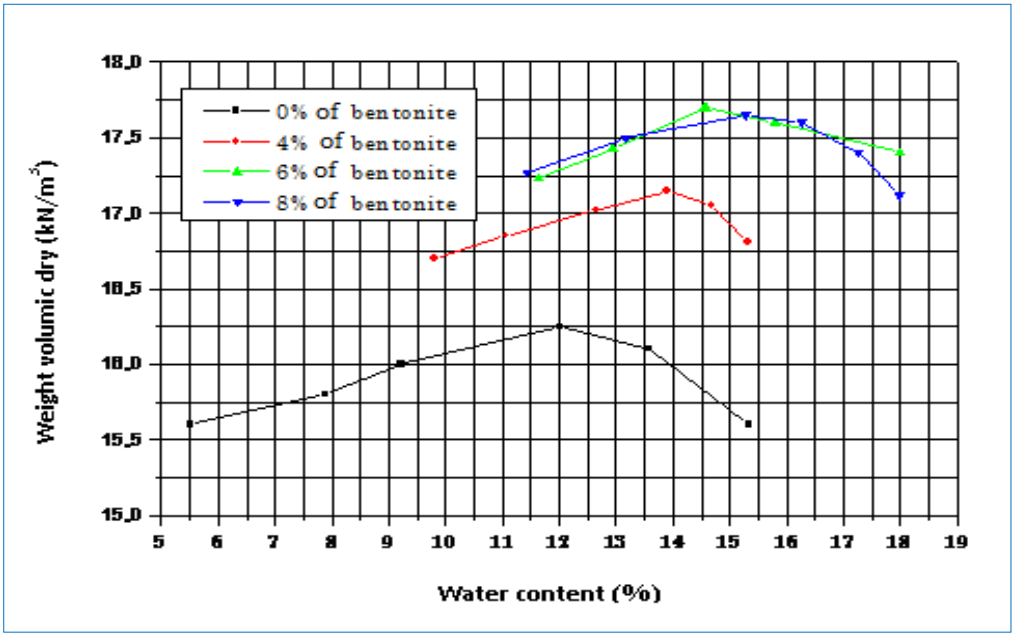

Figure 3. Weight volumic dry versus the water content, for the bentonite concentration.

3.2.2 Permeability tests

Permeability was measured in the laboratory using a permeameter, constant load or variable load. In all permeability tests, the samples were beforehand saturated and the results were collected after stabilization of each test permeability coefficient. The stabilization lasted beyond one week. For reproducibility of the tests, we performed for each concentration of bentonite, two samples with more than twenty readings with the date, time and temperature.
The permeability must however be brought to a reference temperature, usually 20 ° C. For pH it is almost always in the range of 6.5 to 9.
The results of the permeability tests are summarized in Table 4.

Table 4. Results of the permeability tests.

Percentage of bentonite	Sample (1) k (m/s)	Sample (2) k (m/s)
0 %	8.02 E-5	7.93 E-5
4 %	5.20 E-5	5.20 E-5
6 %	7.80 E-7	1.72 E-6
8 %	1.72 E-9	8.2 E-10

The Figure.4 shows the development of the permeability as a function of the concentrations of bentonite.

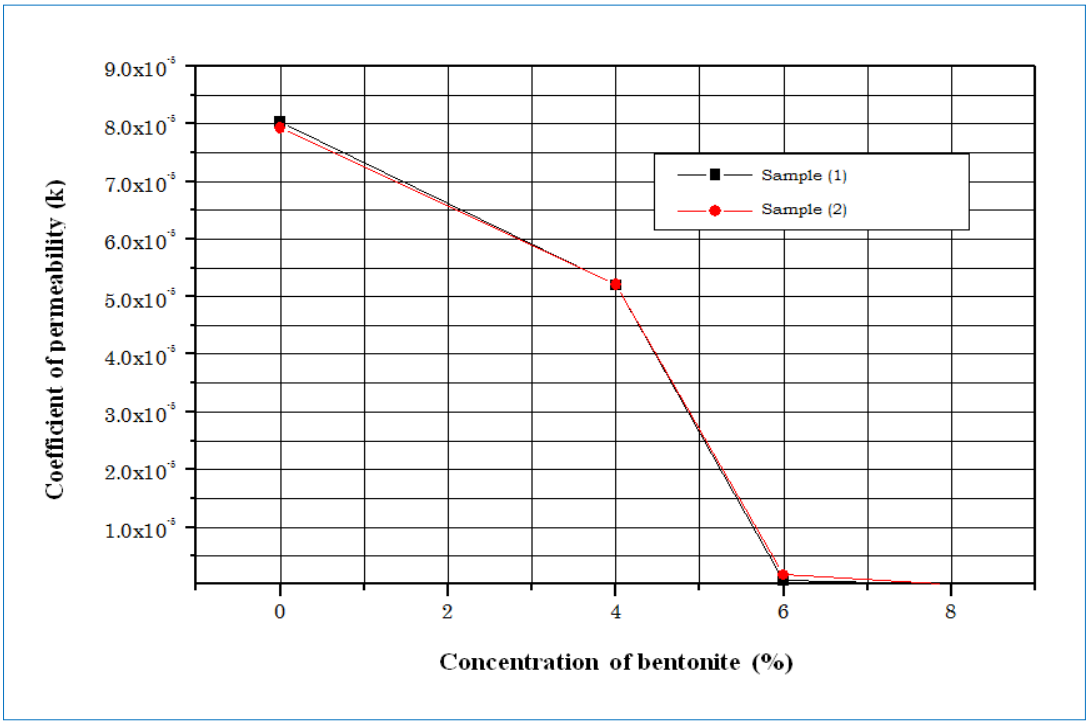

Figure 4. Evolution of permeability as a function of bentonite concentration.

3.3 Infiltration tests of pollution

Using the permeameter variable load, the infiltration test was carried out on a sample which consists of compacted mixture of 92% sand and 8% of bentonite. The sample of this coefficient of permeability is of 8,2.10^{-10} m/s, has the maximum value of permeability coefficients.
The results obtained show the presence of a very high organic content; they confirm that the resulting water infiltration tests is polluted and does not meet drinking water standards.
The physicochemical analyzes before and after infiltration, were made at the laboratory of the National Hydraulic Resources Agency (ANRH) in Algiers.

3.3.1 Physico-chemical composition of the water before infiltration

The analysis results (Table.5) confirm that the water meets the standards of physicochemical potability, subject to bacteriological analysis.

3.3.2 Physico-chemical composition of the water after infiltration

In the presence of very high levels of ammonium and organic matter, the results confirm that this polluted water is of very poor quality and unsuitable for consumption (Table.6).

Table 5. Results of chemical analysis of the water before infiltration.

Physico-chemical parameters and overall mineralization	results	maximum admissible value	pollution parameters	results	maximum admissible value
pH	7,33	6.5 < PH < 9	Ammonium NH4+ (mg/l)	0,05	0,5
Conductivité (ms/cm)	0,98	2,80	Nitrite NO2- (mg/l)	0,00	0,10
Résidus sec à 110°	681	2000	Nitrate NO3- (mg/l)	12,83	50,00
Calcium Ca++ (mg/l)	97	75 - 200	O. Phosphates PO4--- (mg/l)	0,00	0,50
Magnésium Mg++ (mg/l)	26	150,00	Fluorure F- (mg/l)	0,47	0,8 – 2
Sodium Na+ (mg/l)	74,2	200,00	Organic materials (mg/l)	3,00	3,5
Potassium K+ (mg/l)	1,06	20,00	-	-	-
Chlorure Cl- (mg/l)	142	200 – 500	-	-	-
Sulfate SO4 -- (mg/l)	116	200 – 400	-	-	-

Table 6. Results of chemical analysis of the water after infiltration.

Physicochemical parameters and overall mineralization	results	maximum admissible value	pollution parameters	results	maximum admissible value
pH	8,42	6.5 < PH < 9	Ammonium NH4+ (mg/l)	**5,66**	0,5
Conductivité (ms/cm)	0,00	2,80	Nitrite NO2- (mg/l)	0,00	0,10
Calcium Ca++ (mg/l)	26	75 – 200	Nitrate NO3- (mg/l)	0,00	50,00
Magnésium Mg++ (mg/l)	5	150,00	O.Phosphates PO4--- (mg/l)	0,30	0,50
Sodium Na+ (mg/l)	**407,8**	200,00	Fluorure F- (mg/l)	-	0,8 – 2
Potassium K+ (mg/l)	3,70	20,00	Organic materials (mg/l)	**51,00**	3,5
Chlorure Cl- (mg/l)	250	200 – 500	-	-	-
Sulfate SO4 -- (mg/l)	335	200 - 400	-	-	-

4 Discussion

Depending on the permeability standards required ($k < 10^{-9}$ m / s) for waterproof landfills technical barriers, we find that the 8% of the bentonite mixed sand used are sufficient.
But, environmentally, infiltration results show the detrimental effects of the presence of Sludge of pressings in Class 1 landfills.

This implies that the sludge of pressings should not be rejected in technical landfills with household garbage.

5 Conclusion

The results concluded that:

- ✓ For bentonite contents less than 6%, the value of permeability coefficient is almost always remained in the order of 10^{-5} m / s.
- ✓ For greater than or equal to 6% levels, the value of the permeability coefficient increases of 10^{-7} m / s for a percentage of 6% at 10^{-10} m / s for a percentage of 8%.
- ✓ The presence of bentonite in different percentages in the compacted sand-bentonite mixture is a reducing element of the permeability.

Testing has also arrest that, for a coefficient of permeability in the order of 10^{-7} m/s, the pollutant infiltrates the soil and the water becomes polluted; whereas at 10^{-10} m/s permeability water is highly polluted. This due to the large quantities of Organic materials, Na^{+} and NH^{4+}.

If we consider that our pollutant is not biodegradable and if adding the risk of increasing the permeability coefficient of the foundations of controlled discharges, you should not throw it kind of pollutant in technical landfills; but it is best to think of appropriate collections of operations and treatment in specialized factories.

References

ADEME. (2005). Identification et gestion des sites pollués. Guide méthodologique, ADEME Edition. Paris 2005. PP.32-36.

BENTAL-ENOF. (2010). Etude technique et économique des gisements de M'Zila (Mostaganem) et Hammam Boughrara (Maghnia), Vol I, Rapport Final, BUMIGENE.INC. Monréal (Québec) Canada H3B 1P5.

BRGM. (2001). Guide sur le comportement des polluants dans les sols et les nappes. Documents du BRGM, N° 300, France. 2001. PP.26-33.

CNIID. (2001). Un danger potentiel prés de chez vous. Centre national d'information indépendante sur les déchets. Dossier de synthèse. Paris. France, 2005. PP. 1-4.

Debieche, M. (2007). Imperméabilisation d'un matériau pulvérulent par ajout de bentonite. Mémoire de magister. Faculté de génie civil. USTHB. Alger. Algérie, 2007. PP.72-97.

Didier, G. and Cavalcante Rocha, J. (1998). Définition des conditions optimales de traitement en place d'un sol perméable en vue de son imperméabilisation, Rap. Subvention N° 90012, Min. de l'environnement, Direction Générale de l'Administration et du Développement, Service de la Recherche et des Affaires Economiques, 215 p.

Dutheil, C. (2003). Dépollution des sols par extraction sous pression réduite. Thèse de Doctorat, INSA, Lyon. France, 2003. PP. 8-29.

Gleason, M.H., Daniel, D.E. and Eykholt, G.R. (1997). Calcium and Sodium Bentonite of Hydraulic Containment Application. Journal of Geotechnical and Geoenvironmental Engineering, 123, 438-445.

Gueddouda. M.K., Lamara, M., Aboubaker, N. and Said, T. (2008). Hydraulic Conductivity and Shear Strength of Dune Sand-Bentonite Mixtures. EJGE, 13, 2008 -Bundle H. 1-15

INERIS. (2005). Note sur les produits de substitution du perchloroéthylène dans les installations du nettoyage à sec. Rapport d'étude N° ERSA-05 n°9. Février 2005. P.12.

Jules, H. (2004). Livre blanc du Chlore (les solvants). BelgoChlor c/o Fedichen. Bruxelles. Novembre 2004. PP. 1-5.

JORADP. (2001). Loi n° 01- 19 du 27 Ramadhan 1422, correspondant au 12 décembre 2001, relative à la gestion, au contrôle et à l'élimination des déchets. Journal Officiel de la République Algérienne. 40ème année. N°77. Mardi 15 Décembre, 2001. PP.7-15.

Komine, H. (2004). Simplified evaluation on hydraulic conductivities of sand-bentonite mixture backfill. Department of Urban and Civil Engineering, Ibaraki University, 4-12-1 Nakanarusawa-cho, Hitachi, Ibaraki, 316-8511, Japan, Available online.

MATE. (2005). Guide de conception des (CET). Ministère de l'aménagement du territoire et de l'environnement. Septembre 2005. Algérie. PP.1-13.

METAP. (2004). Projet régional de gestion des déchets solides dans les pays du mashreq et maghreb. Rapport du pays - Algérie (final). The World Bank. Janvier 2004. PP.1-7.

MATE. (2003). Rapport sur l'état et l'avenir de l'environnement 2003. Ministère de l'aménagement du territoire et de l'environnement. Algérie 2003. PP. 207-220.