ASSESSMENT OF CLOGGING POTENTIAL OF SYNTHETIC ENVELOPES USED IN DRAINAGE OF SALINE SOIL

EVALUATION DU POTENTIEL DU COLMATAGE DE L'ENROBAGE SYNTHETIQUE UTILISE DANS LE DRAINAGE DES SOLS SALINS

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ABSTRACT

Conventional graded granular filter used in subsurface drainage, have given way to the use of synthetic envelopes, which are light, cheaper, offers easy placement and perform equally well as granular filter. There are some general criteria and various tests to select the best envelop for field application. The gradient ratio test (ASTM, D- 5101) is one of the methods used in the laboratory to evaluate the clogging potential of a soil –geosynthetic filtration system.

In the present study, two physical models of permeameter (ASTM D- 5101) were used to carry-out a series of permeability tests by varying geosynthetic type and salinity of water under unidirectional flow condition. The study was done on soil and water collected from south of Iran (Khoramshahr) using three different PLM (pre-wrapped loose material) PP450, PP700 and PP900. The drainage water used had a high salinity, which is common in many drainage projects in south of Iran (EC=22.2 dS/m, SAR=26.27 $(meq/lit)^{0.5}$) in comparison to the normal water (EC=0.78dS/m, SAR=1.23 $(meq/lit)^{0.5}$)). Permeability tests were carried out at 5 different hydraulic gradients (1, 2.5, 5, 7.5, and 10). Variations of discharge, hydraulic conductivity and gradient ratio (the ratio of the hydraulic gradient through a soil – geosynthetic filtration system to the hydraulic gradient through the soil alone) were measured and investigated statistically as factorial experiments in a RCB design.

Based on permeability tests results, hydraulic conductivity and gradient ratio of all three specimens (PP450, PP700, PP900), were found susceptible to salinity of water. Based on all tests gradient ratios result, the probability of clogging by applying saline water was considered higher. To conclude, in three specimens the permeability test results strongly

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differed between the use of saline water and the use of normal water. This shows that the water salinity should be an important concern in assessing the clogging potential and flow rate of a filtration system.

Key words: *Synthetic envelop, drainage, clogging, hydraulic conductivity, Khoramshahr's wastewater.*

RESUME ET CONCLUSIONS

Le granulaire calibré filtre qui sont couramment utilisées dans le drainage souterrain, rencontrent des difficultés diverses qui ont conduit à l'utilisation de l'enveloppe synthétique. enveloppe synthétique peut être justifiée sur granulaires économie filtre amélioré en raison de leurs performances comparables, et la facilité de placement. A fin de choisir son enveloppe, il ya des critères généraux et divers tests pour confirmer les meilleurs avant de les mettre dans le domaine. Le test du rapport de gradient (ASTM D 5101) est l'une des méthodes utilisées en laboratoire pour évaluer le potentiel de colmatage d'un système de filtration du sol-géosynthétique.

À cette fin, deux modèles physiques de perméamètre (conçus selon la norme ASTM D- 5101) utilisés pour le transport-une série d'essais de perméabilité en faisant varier le type géosynthétiques et de la salinité de l'eau. Cette méthode d'essai couvre un test de performance applicable pour déterminer la perméabilité du sol - enveloppe synthétique du système et le colmatage des conditions d'écoulement unidirectionnel. L'étude a été réalisée sur le sol et l'eau qui ont été collectés depuis le sud de l'Iran (Khoramshhr) en utilisant trois différents PLM (pré-emballés une substance non agglomérée) PP450, PP700 PP900 et. Un point caractéristique de cette recherche est l'application d'eau de drainage avec une salinité élevée qui est une difficulté commune à des projets de drainage de nombreux dans le sud de l'Iran (EC = 22,2 dS / m, SAR = 26.27 (meq / litre) ^{0,5}) par rapport à l'application d'eau normale (EC = 0.78dS / m, SAR = 1,23 (meq / litre) ^{0,5})). Des essais de perméabilité ont été effectuées à 5 hydrauliques gradient différentes (1, 2,5, 5, 7,5, et 10). Variations de la décharge, la conductivité hydraulique et le rapporte de gradient (le rapporte de gradient est défini comme le rapport entre le gradient hydraulique par un système de filtration du sol géosynthétiques pour le gradient hydraulique dans le sol seul) ont été mesurées et analysées de façon statique comme des expériences factoriels sous la forme de randomisés de conception complet.

Basé sur les résultats des tests de perméabilité, la conductivité hydraulique et le taux de gradient de tous les trois échantillons (PP450, PP700, PP900), étaient sensibles à la salinité de l'eau qui a employé dans des essais de perméabilité. Les résultats ont démontré que plus la salinité de l'eau la partie inférieure de la conductivité hydraulique et le taux de rejet de débit dans tous les échantillons, la conductivité hydraulique moyen en appliquant de l'eau normale étaient 1,29, 1,36, 1,26 fois de la conductivité hydraulique moyenne de l'application d'eau saline. Les résultats obtenus a indiqué que, dans chaque gradient hydraulique, la conductivité hydraulique du système sol-géosynthétique réduit par le mouvement des particules du sol vers l'enveloppe et les débits de pointe atteignent des valeurs dans le premier gradient hydraulique. En outre, la réduction des rejets de débit passant par les systèmes de filtration de l'eau par l'application normale a été moins sévère que l'utilisation de l'eau saline. Sur la base de tous les tests de ratios gradient conséquent, il peut conclure que aucun des échantillons *de l'enveloppe ont été sensibles à l'encrassement même par l'utilisation des sols salins et de l'eau, bien que la probabilité de colmatage en appliquant l'eau salée est plus élevé. Les ratios obtenus gradient atteint un sommet de o.85 en appliquant l'eau salée.*

Enfin, la performance du PP450 était plus approprié que les enveloppes d'autres en termes d'application de l'eau de salinité différente. Pour conclure, en trois exemplaires les résultats des tests de perméabilité varient fortement en appliquant l'eau salée par rapport à l'utilisation de l'eau normale. Cela montre que la salinité de l'eau devrait être une préoccupation importante pour évaluer le potentiel de colmatage et le débit d'un système de filtration.

Mots clés : *Enrobage synthétique, drainage, colmatage, conductivité hydraulique, eau perdue de Khoramshahr.*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

Synthetic envelopes are highly effective filters in numerous applications. Due to their comparable performance, improved economy, consistent properties and ease of placement, these materials have been used successfully to replace graded granular filters in almost all drainage applications (Stuyt et al; 2000): Their advantages are:

1. Use of less or lower quality drainage aggregate;
2. Use of smaller sized drains;
3. Possible elimination of collector pipes;
4. Expediency of construction;
5. Lower risk of aggregate contamination and segregation;
6. Reduced excavation; and
7. Less wasted materials.

It is also to be noted that though the use of organic envelopes has become widespread, their decomposition due to microbes is a major disadvantage especially in Iran. Therefore, the synthetic envelopes, have gained popularity quite rapidly. Their application is commonplace in North America and Europe, and is growing fast in countries like Egypt, Pakistan, and India. Synthetic envelopes can be either strips of geosynthetic wrapped around the drainpipe, or loose synthetic fiber wrappings. Most loose synthetic fiber wrappings are manufactured from recycled material, like polypropylene waste fibers from the carpet industry.

Approximately, for all projects in Iran the cost of material and transportation of synthetic materials is lower than the cost of gravel which nowadays is the most material used as drainage envelop in Iran. The PLM envelopes are permeable structure of loose randomly oriented yarns, fibers, filament, grains granular or beads, around a corrugated drainpipe made by specialized companies. Most PLMs are manufactured from recycled material like polypropylene waste fibers from the carpet industry. Also increasing growth of petrochemical industries in Iran, provide possibility of manufacturing these products in Iran.

In order to choose the proper envelope, there are some general criteria and various tests to confirm the selected right product. In lieu of time consuming field tests, laboratory tests are of short duration and are relatively less expensive. Several experimental techniques can be applied to determine physical and hydraulic properties of synthetic envelopes (Hassanoghli, 2009). One of these laboratory experimental methods is permeability test which is based on determining the soil -synthetic envelope system permeability and clogging behavior (ASTM; 1993).

In this study, the soil and drainage water were collected from one of the drainage projects in south of Iran (Khoramshahr) which show significant salinity, to simulate real condition in permeability tests. To summarize, this study presents examining performance of three synthetic envelopes (PP450, PP700, and PP900) through common permeability test by applying saline soil and water as compared to use normal water and soil.

2. EQUIPMENT

In the present study, permeability test was done for determining the soil-synthetic envelope system permeability and clogging behavior for cohesion less soils under unidirectional flow conditions (ASTM; 1993). The test requires setting up a cylindrical, clear plastic permeameter (Fig. 1 and Fig. 2) with a PLM and soil, and passing water through this system at varying heads. Measurements of heads and flow rates were taken at different time intervals.

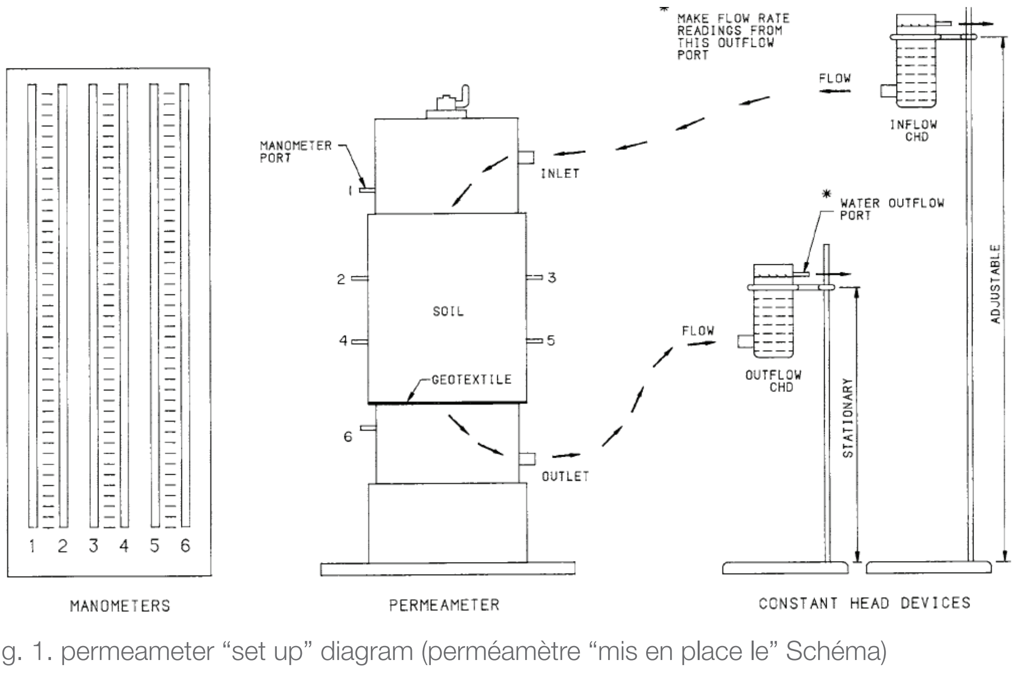

Fig. 1. permeameter “set up” diagram (perméamètre “mis en place le” Schéma)

The changes in gradient ratio values with time versus the different system hydraulic gradients, and the changes in the rate of flow through the system were noted carefully. Soil-envelope permeameter equipped with support stand, soil-envelope support, Two Constant Water Head Devices, one mounted on jack stand (adjustable) and one stationary (Fig. 1). The values of hydraulic gradients used in these tests were established by moving up and down the inlet reservoir which were equal to (1, 2.5, 5, 7.5 and 10) respectively. Tests were repeated three times, each time for a constant hydraulic head. The constant head system is shown in Figure 3.

Fig. 2. permeametr apparatus (appareil perméamètre)

Fig. 3. Saline water reservoir (réservoir d'eau saline)

3. ENVELOPE MATERIAL

Three synthetic PLMs (pre wrapped loose material) which are permeable structure consisting of loose, randomly oriented yarns, and usually wrapped around the corrugated plastic drainpipes by specialized companies were used in present study. One circular specimen from each swatch was cut in the laboratory sample with the specimen having a diameter of 110 mm (4.33 in). Table 1 shows the properties of these three geosynthetics materials.

Table1. Properties of geosynthetics materials (Propriétés des matériaux géosynthétiques)

Fiber diameter (mm)				Thickness (mm)	Mass per unit area (g/cm^2)	O_{90}	K_e(m/day)	Synthetic envelope
1.12	0.76	0.53	0.46	5.2	0.0607	450	0.6788	PP450
1.15	0.84	0.68	0.46	5.6	0.0619	700	0.6967	PP700
1.22	0.88	0.73	0.46	5.8	0.0638	900	0.6994	PP900

3.1 Criteria for pre-wrapped envelopes

In The Netherlands, recommendations for the design and application of PLMs have been developed on the basis of concurrent research projects, theoretical studies, mathematical modeling, empirical studies in experimental fields, analogue modeling in laboratories and practical experience over a 30-year period: 1960-1990 (Stuyt, 1992a). Specimens were analyzed by some of these criteria which are listed below.

Thickness

According to the provisional EN-standard (CEN/TC155/WG18, 1994), the following minimum thicknesses are required (Vlotman et al; 2000):

- Synthetic, fiber PLMs: 3 mm (e.g. PP fibers).
- Synthetic, granular PLMs: 8 mm (e.g. polystyrene beads).
- Organic, fibers PLMs: 4 mm (e.g. coconut fibers).
- Organic, granular PLMs: 8 mm (e.g. wood chips, sawdust).

Mass per unit area

The mass per unit area is not a selection criterion and therefore not specified. Mass is determined as a control measure for uniformity and conformity. According to the provisional EN-standard, the mass may not deviate by more than 25% of the mass specified by the manufacturer in order to ensure homogeneity.

Characteristic opening size and retention criterion

The characteristic opening size, derived from the pore size distribution or porometric curve of the envelope, is the most important selection criterion because it determines the effectiveness of the envelope to retain the surrounding soil material. In The Netherlands and in Belgium, the successfully applied retention criterion O_{90}/d_{90} for envelopes was adopted as the major design parameter. Recommendations for envelope applications are also based on some additional considerations.

$1<O_{90}/d_{90}<2.5$ for envelope thickness<1mm (1)

$1<O_{90}/d_{90}<3$ for envelope thickness between 1 and 3 mm (2)

$1<O_{90}/d_{90}<4$ for envelope thickness between 3 and 5 mm (3)

$1<O_{90}/d_{90}<5$ for envelope thickness < 5 mm (4)

Hydraulic conductivity

The hydraulic conductivity of envelopes should be greater than that of the soil. A substantial reduction in entrance resistance occurs when $K_e/K_s > 10$, where K_e is the hydraulic conductivity of the envelope and K_s that of the soil.

4. TEST WATER AND SOIL PREPARATION

Test water should be maintained at room temperature about 16 to 27°C (60 to 80°F), saline water prepared from drainage project of Khoramshahr's wastewater (EC: 22.2 dS/m). All of the permeability tests were also carried out by with normal water of EC: 0.7dS/m.

The EC of soil collected from south of Iran, was 167dS/m. For processing the soil the air-dried (for 3 days) material passed through 10 mm (3⁄8 in.) and retained on the No.10 sieve was subjected to a second round of grinding to ensure that the sample has been broken down into individual grains. A representative sample weighing about 1300 g (or 3000 g for the 150-mm diameter drain pipe) was subdivided into four parts using a soil splitter, with one part to be used for the tests. Air-dried processed soil was placed above the support cloth to a depth of 103 mm (4.12 in.). The final depth of soil after settlement will be approximately 100 mm (4 in). The soil was placed carefully into the permeameter with appropriate tool in layers not exceeding 25 mm (1 in.) at a time until the total soil height of 103 mm (4.12 in.) was reached. Table 2 and 3 show the properties of water and soil used in experiments (ASTM; 1993).

Table 2. Chemical Properties of water and soil (Propriétés chimiques de l'eau et du sol)

SAR	SUM	Cations (meq/lit)$^{0.5}$				SUM	Anions (meq/lit)$^{0.5}$				PH	EC (dS/m)	Specimen properties
		K^+	Na^+	Ca^{+2}	Mg^{+2}		SO_4^{-2}	Cl^-	HCO_3^-	CO_3^{-2}			
45.18	1697.40	-	901.00	141.00	655.00	1697.00	340.80	1354.00	2.20	-	7.33	169.30	Soil
26.27	226.43	-	155.43	16.00	54.00	225.37	42.47	179.50	3.40	-	7.90	22.20	Saline water
1.23	10.45	-	2.45	4.00	4.00	10.09	5.89	2.00	2.40	-	7.23	0.78	Normal water

Table 3. Physical Properties of soil (Propriétés physiques du sol)

Specimen properties	Organic Carbon%	Clay%	Silt%	Loam%	Lime (%TNV)	Texture	Plaster%
Soil	2.928	29.37	52.30	18.33	35.00	Silty Clay Loam	2.29

5. PROCEDURE

After fitting the constant head devise, the manometer tubes, the outlet tubes, overflow tubes (Figs. 1 through 5) to their corresponding permeameters, the geosynthetic-soil-water system was saturated. The inflow level was adjusted to achieve a hydraulic gradient (i) of 1.

Then flow was let in and the initial starting time was recorded and the following data at 0, 0.5,1, 2, 4, 6, and 24 h from the initial starting time were recorded : the time in hours (cumulative), the flow rate from the system; time in seconds (t) for a measured quantity of flow (Q) in cm^3 (for a minimum duration of 30 s and a minimum quantity of flow of 10 cm^3), the temperature (T) of the water in the system in ^0C, the water level readings from the individual manometers. After the final reading when the system has stabilized, the inflow was raised to obtain next hydraulic gradient and measurements were repeated, and so on till i = 10. The test was run continuously (Anon; 2006), each test repeated three times.

6. CALCULATION

Hydraulic Gradient (i): The hydraulic gradient was Calculated as follow (ASTM; 1993)

$$i = D_h/L \quad (5)$$

Where, D_h = difference in manometer readings for soil zone analyzed, manometer 1 minus manometer 6, cm, and L = length or thickness of soil between manometers being analyzed, cm

System Permeability (k): the system permeability was obtained at the temperature of the test and corrected to 20°C using Eq (7).

$$K_T = \frac{V}{i \times t \times A \times 100} \quad (6)$$

$$K_{20} = \frac{K_T \times \mu_T}{\mu_{20}} \quad (7)$$

Where:

k_T = system permeability at test temperature, m/s,

k_{20} = system permeability at 20°C, m/s,

Q = quantity of flow measured, cm^3,

i = hydraulic gradient of the system,

A = cross-sectional area of the specimen, cm^2,

t = time for measured quantity of flow, s,

μ_T = water viscosity at temperature of the test, and

μ_{20} = water viscosity at 20°C.

Gradient Ratio: For each hydraulic gradient the gradient ratio, GR, was reported for the system using Eq. (8) and data for the final time interval used, Shows the meaning of the values in the equation schematically.

$$\Delta h_S = \frac{(M_2 - M_4) + (M_3 - M_5)}{2} \quad (8)$$

$$\Delta h_{SF} = \frac{(M_4 - M_6) + (M_5 - M_6)}{2} \quad (9)$$

M_n = the manometer reading, cm, for the manometer numbered n.)

L_s = 5.10 cm (2 in.), and

L_{sf} = 2.55 cm (1 in. + the specimen thickness)

7. RESULTS

7.1 Physical properties

By measurements of specimen's physical properties, it was clearly indicated that all three specimens have the minimum thickness which was introduced to guarantee a complete cover (CEN/TC155/WG18, 1994). the minimum thicknesses which was required was 3 millimeter. The three specimens had thicknesses as: PP450=5.2 mm, PP700=5.6mm, PP900= 5.8mm, more than the required minimum of 3 mm.

Mass measurements results show that deviation of mass per unit area for PP450, P700, and PP900 was respectively 12%, 21% and 17%, all of which were lower than the permissible maximum of 25%.

The characteristic opening size, derived from the pore size distribution or porometric curve of PP450, PP700 and PP900, was respectively, 450, 700 and 900 µm. Considering the d_{90} of 140 µm, specimens had O_{90}/d_{90} ratios of 3.22, 5 and 6.44, which PP450 and PP700 satisfies Eq (4) criteria and therefore can be trusted as envelope drainage materials.

7.2 Variation of hydraulic properties

Hydraulic conductivity

Fig (4) shows the variation of specimens' hydraulic conductivity (k) when applying water with two different salinity range. The average k in all hydraulic gradient decreased in all specimens in all due to reduction of the number of active openings in synthetic envelopes that occurs gradually, when it is in contact with soil. Clogging, on the other hand, is with time of the number of active openings in an envelope due to gradual accumulation of particles inside and on specimen's surface.

By comparing the k graphs when applying saline water, was found that higher salinity of water caused reduction in k. High salinity of water decreases soil stability and therefore caused substantial soil dispersion. As a result, it causes increasing soil particle movement toward envelope's pores. In regard to Table 4, which represents soil – envelope k, the average k when applying normal water (EC=0.78dS/m) for three synthetic envelopes PP450, PP700 and PP900 respectively was 1.29, 1.30, 1.26 times of average k when saline water (EC=22.2dS/m) was used. Table 5 shows percentage of k variation between normal and saline water use. Since the k variation when using saline water was higher than when using normal water, it indicated stronger probability of clogging in permeability tests using saline water. The results indicated that in each hydraulic gradient, k of soil-geosynthetic system reduced by soil particle movement toward envelope and the flow rates reached peak values in the hydraulic gradient of 1. The reduction in flow discharge passing through filtration systems when using normal water was less than the case of saline water use. The average discharge under saline water flow was less than average discharge when normal water was used. Hence, the series of permeability tests demonstrate some clogging behavior by applying saline water in all the three specimens.

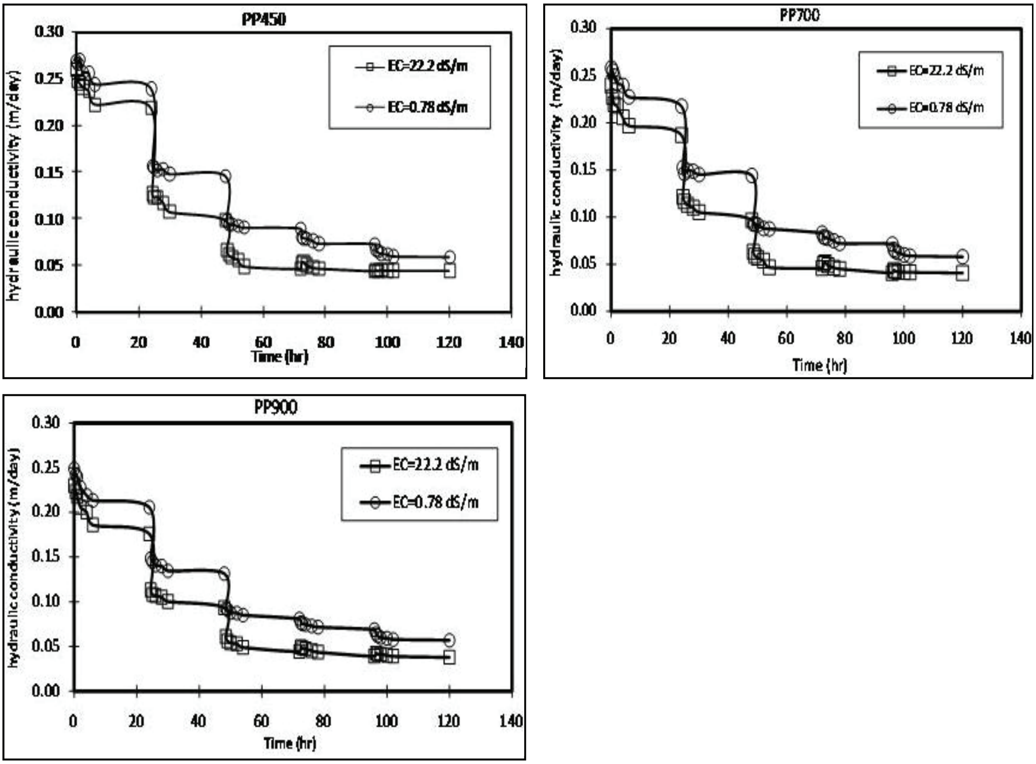

Fig. 4. Hydraulic conductivity of soil – envelope system (La conductivité hydraulique du sol - système d'enveloppe)

Table 5. Percentage of hydraulic conductivity variety (pourcentage de la variété la conductivité hydraulique)

PP450		PP700		PP900		Hydraulic gradient
EC=22.2dS/m	EC=0.78dS/m	EC=22.2dS/m	EC=0.78dS/m	EC=22.2dS/m	EC=0.78dS/m	
23%	17%	23%	15%	15%	11%	1
17%	11%	20%	5.4%	22%	6.4%	2.5
27.3%	12%	27.2%	10%	29%	8%	5
21%	10%	24%	9.6%	15%	8.6%	7.5
11.5%	10%	12.6%	7%	10.6%	2.3%	10

Figures 5 and 6 represent k vs. i regressions for all three specimens in case of applying saline and normal water. It clearly demonstrates the higher k when using normal water than when using saline water.

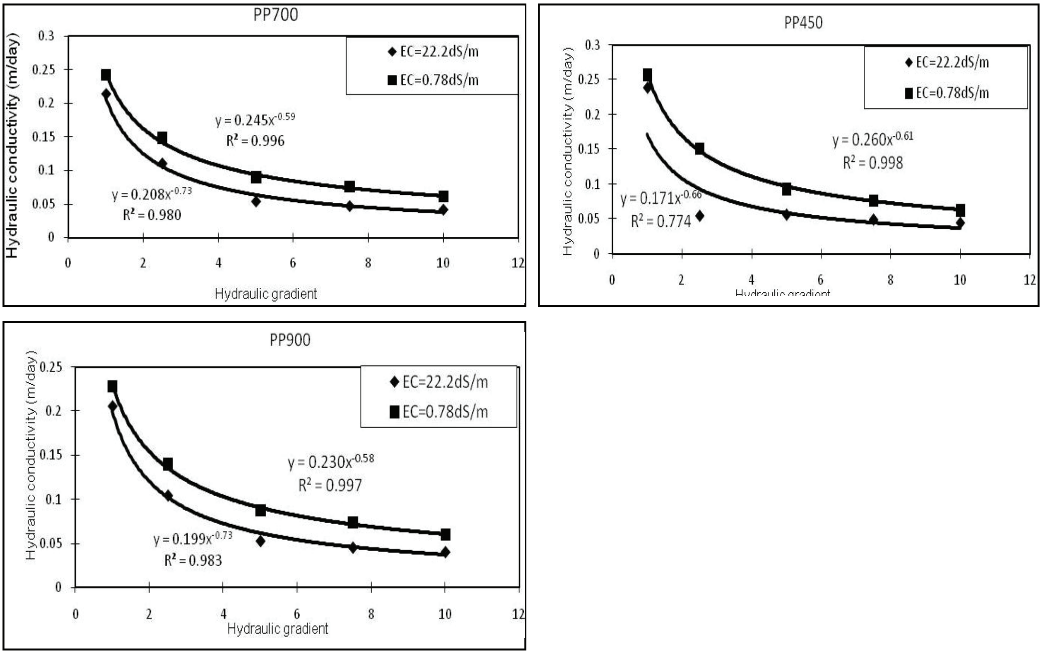

Fig. 5. Regression chart of hydraulic conductivity in terms of hydraulic gradient (tableau de régression de la conductivité hydraulique)

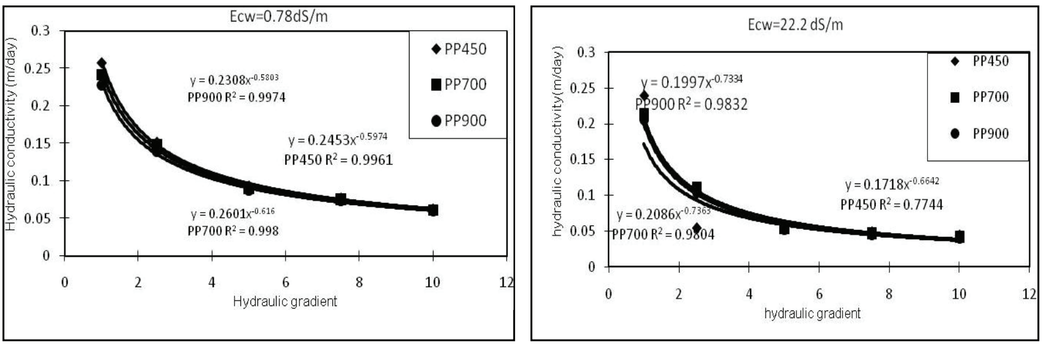

Fig. 6. Regression chart of hydraulic conductivity (tableau de régression de la conductivité hydraulique)

7.3 Gradient ratio

Gradient ratio is one of the effective parameters in predicting clogging potential of synthetic envelopes.

Based on all gradient ratio tests, it can be concluded that none of the envelope samples were susceptible to clogging even by using saline soil and water, although the probability of clogging by applying saline water was higher. Based on Table 6, the gradient ratios reached a peak of 0.85 by using saline water. The performance of PP450 was better than the other envelopes in terms of applying water with different salinity. To conclude, in three specimens the permeability test results strongly varied between the use of saline water and normal water. This shows that the water salinity should be an important concern in assessing the clogging potential and flow rate of a filtration system. Gradient ratios revealed that none of three synthetic envelopes (PP450, PP700 and PP900) were susceptible to mineral clogging. In all cases, the gradient ratio was less than 1 even by applying saline water. However, the ratio was higher for using saline water than for using normal water. In all tests, the gradient ratio reached its minimum at hydraulic gradient of 10. Figure 7 shows gradient ratio in terms of hydraulic gradient for PP450, PP700 and PP900.

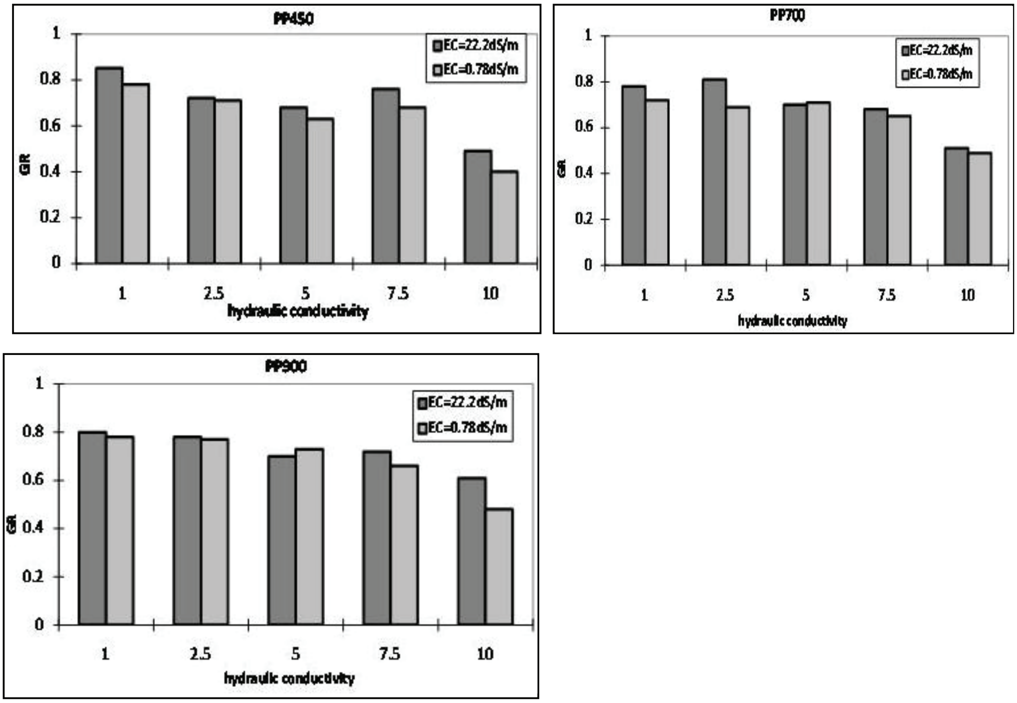

Fig. 7. Gradient ratio of three synthetic envelopes (rapporte de gradient de trois enveloppes synthétiques

Table 6. Gradient ratio of three synthetic envelopes (rapporte de gradient de trois enveloppes synthétiques

PP900		PP700		PP450		Hydraulic gradient
EC=0.78dS/m	EC=22.2dS/m	EC=0.78dS/m	EC=22.2dS/m	EC=0.78dS/m	EC=22.2dS/m	
0.78	0.8	0.72	0.78	0.78	0.85	1
0.77	0.78	0.69	0.81	0.71	0.72	2.5
0.73	0.7	0.71	0.7	0.63	0.68	5
0.66	0.72	0.65	0.68	0.68	0.76	7.5
0.48	0.61	0.49	0.51	0.4	0.49	10

7.4 Statically analysis of permeability test's result

Statically analysis was performed by SPSS, in order to estimate obtained data in regard to four different effective factors (salinity of water, synthetic envelope type, hydraulic gradient and repeat) were investigated statically as factorial experiments in the form of randomized complete design. Table (7) represents statically analysis results.

Table 7. Variance analysis of hydraulic conductivity (L'analyse de variance de la conductivité hydraulique)

Mean of square (MS)	Sum of square (SS)	Freedom degree (df)	Variety source
0.005 **	0.005	1	salinity
0.170 **	0.0678	4	gradient
0 **	0.004	2	envelope
0 ns	0	2	repeat
0.002 **	0.008	4	Envelope ×salinity
0 **	0.002	8	salinity× gradient
0 **	0.002	8	Envelope × gradient
0 **	0.005	8	salinity×envelope×gradient

**, *and ns Means respectively being significant in 1 % and 0.5 % and insignificantly

Statical analysis results of hydraulic conductivity variance revealed that salinity- hydraulic gradient; synthetic envelope type and reciprocal effect of salinity – hydraulic gradient, envelope-salinity, salinity-gradient and gradient – envelope - salinity make significant difference on hydraulic conductivity of soil – envelope system. However, repeat didn't have any significant difference on hydraulic conductivity. Statically analysis results revealed that high salinity of water, high soil particle movement and high mineral clogging of synthetic envelope. Statically analysis of gradient ratio which is given in table (8) shows that salinity has significant effect on all synthetic envelopes, in other words there is significant difference between gradient ratios of all synthetic envelope on permeability tests by applying saline water (EC=22.2dS/m) and normal water.

Table 8. Vvariance analysis of gradient ratio (L'analyse de variance de la rapporte gradient)

Mean square (MS)	Sum of square (SS)	Freedom degree	Variety source
0.222 **	0.222	1	salinity
1.689 **	1.564	4	gradient
0.335 **	1.985	2	envelope
0 ns	0.002	2	repeat
0.008 **	0.021	4	Salinity ×envelope
0.001 ns	0.004	4	Salinity ×gradient
0.008 **	0.095	8	Envelope ×gradient
0.005 **	0.042	8	Envelope ×salinity × gradient

**, *and ns Means respectively being significant in 1 % and 0.5 % and insignificantly

Based on observed means Duncan tests result which is given in table (9), it can be concluded that hydraulic conductivity of soil- envelope system and gradient ratio are susceptible to the type of synthetic envelope which applied in permeability tests. In other words there is significant difference between permeability test's result in case of applying different synthetic envelope type (PP450, PP700 and PP900) in terms of hydraulic conductivity, the maximum amount was related to permeability test by applying synthetic envelope PP450 and the minimum amount was occurred in permeability test in case of utilization of PP900. Moreover, the maximum and minimum amount of gradient ratio was related to applying PP900 and PP450 respectively. Generally, Duncan test's result proved that, the performance of PP450 as a synthetic envelope is more suitable than two other geosynthetics which used in these permeability tests in case of applying either saline or normal water.

Table 9. Means comparison for hydraulic conductivity and gradient ratio (Duncan test) Moyens de comparaison pour la conductivité hydraulique et le taux de gradient (test de Duncan)

Gradient ratio (GR)		Hydraulic conductivity K(m/day)		Synthetic envelope
0.668 c	30	0.1256 a	30	PP450
0.675 b	30	0.1171 b	30	PP700
0.703 a	30	0.1143 c	30	PP900

Duncan test results are given in table (10) which is considering hydraulic gradient as variety source. Regarding Duncan tests results, it found that the maximum amount of gradient ratio and hydraulic conductivity are occurred at hydraulic gradient of 10. So the more hydraulic gradient, the more water discharges.

Table 10. Mean comparison for hydraulic conductivity and gradient ratio (Duncan test)

Gradient ratio (GR)		Hydraulic conductivity (m/day)		Hydraulic gradient
0.785 [a]	18	0.2310 [a]	18	1
0.745 [b]	18	0.1074 [b]	18	2.5
0.691 [c]	18	0.0723 [c]	18	5
0.690 [c]	18	0.0613 [cd]	18	7.5
0.491 [d]	18	0.0526 [d]	18	10

8. CONCLUSIONS

Hydraulic conductivity and gradient ratio's result of permeability tests which were carried out on PP450, PP700 and PP900 by applying saline and normal water and their statically analysis revealed that all three synthetic envelopes' permeability are susceptible to salinity of water.

The average hydraulic conductivity of soil – geosynthetic system of PP450, PP700 and PP900 in case of applying saline water decreased 26, 30 and 29 percent in comparison with hydraulic conductivity in terms of applying normal water respectively. Moreover statically analysis results revealed that these differences are significant.

Increasing gradient ratios and approaching to 1 in case of applying saline water led to converting soil- synthetic system to vulnerable condition.

So it seems notable that in spite of observed variety and approaching to crucial condition, however still all permeability tests' results stayed in quite acceptable limitation. On the other hand, considering permeability test's results in case of applying saline and normal water, physical properties and statically analysis of all specimens it can be obtained that the performance of PP450 is more suitable than two other synthetic envelopes in case of applying saline and normal water.

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