Geotextiles in Green Roof applications

As many know Geotextiles play an important role within Green roofs. Yet hardly anyone knows what the technology behind Geotextiles is; how they work and what is important when dealing with Geotextiles and Green Roofs.

The use of Geotextiles in filter applications is probably the oldest, most widely known, and most used function of Geotextiles. In Green Roof applications the Geotextile is placed between a drain core and growing medium.

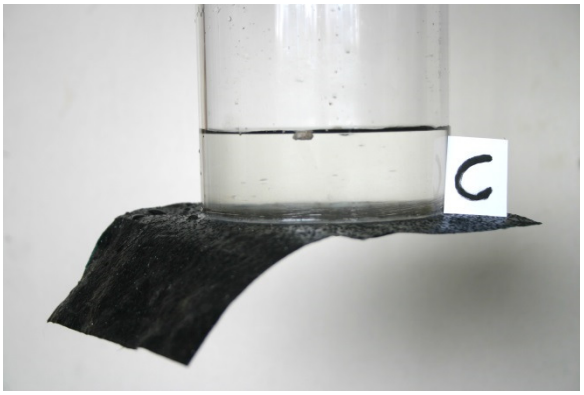
The capacity of water passing through a Geotextile is referred to as permittivity. Water and any particles suspended in the water which are smaller than a given size flow through the Geotextile. Those soil particles larger than that size are stopped and prevented from being carried away.

Geotextiles substitute and serve the same function as a traditional granular filter. Both the granular filter and the Geotextile must allow water to pass without significant buildup of hydrostatic pressure. Irregular opening sizes within Geotextile are not preferred because opening sizes are unpredictable. Long term clogging is a concern when Geotextiles are used for filtration, especially within Green Roof applications.

Objective of this study:

BC Green Roof has in depth knowledge and expertise when it comes to the technology behind Green Roofs. We have received comments from several individuals that they find it hard to find in depth information with regards to the technology behind Green Roofs**. We hear that benefits of Green Roofs are rather easily to find, however, information regarding detailing and the inner workings of Green Roofs is hard to find.**

This article sheds some light on Geotextiles and visualizes how they work.



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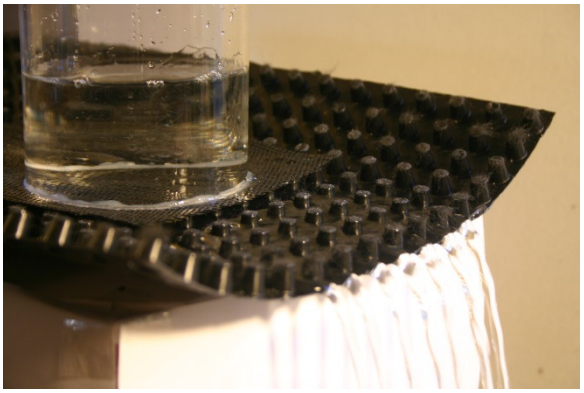

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Why should this information be interesting to you?

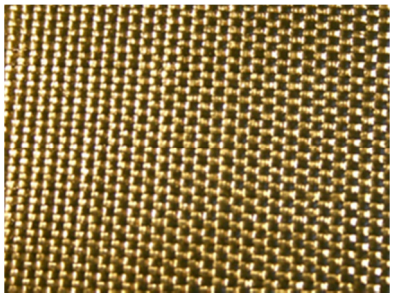
In the Pacific Northwest the majority of our rainfall happens in the fall and winter and as the world is adapting to climate changes, we noticed an increase in peak, short duration rain intensity.

The City of Victoria had over 17 heavy rain storms between 1968 and 1984 where measurements were recorded of up to 100 mm of rain in a 24 hour cycle. Victoria BC reached measurements of 146mm in 1986 and 138 mm in 2003. Parksville, BC was hit with a record downpour of 33mm of rain in only 18 minutes in September 2013.

Depending on the location average maximum precipitation in a 24 hour cycle can reach over 300mm (Jordan River 37 year average is 161.3 mm). **Statistics provided by Environment Canada.**

Looking at Intensity Duration Frequency curves (IDF curves) for various municipalities and cities in the region it indicates that a 40mm rainstorm has a 20% probability to occur in a given year and a 60 mm rainstorm a 2% probability.

Common types of Geotextiles:



Woven Monofilament Geotextiles:
This type of filter works on the principle of tightly woven strands of polymer allowing consistent voids in between the strands which allow water to pass through. Although tension strength is not as important as drainage capacity, it often has the highest tension strength.

Woven Geotextiles are often UV- resistant which can be a benefit in case of long exposure to sunlight.

Spun bound Geotextiles:
This type of filter material is produced by continuous filament fibers extruded from spinnerets to form a swirling pattern of fibers across a web. The fiber web is passed through heated rollers or an oven to bond the fibers creating the final product.

The irregular pattern of the fibers unavoidable has irregular voids to allow water to drain through the fibers. This does not mean that they don't drain as fast as woven Geotextiles. However, acting as filter, particles passing through the fibers can get trapped within the fiber, and influence the drainage capacity in the long run.

Needle punched Geotextiles:
Needle punching is a mechanical process which, rather than using heat (Spun bound), fixes the fibers relative to each other by entanglement. Banks of barbed needles compact loose fiber into a labyrinth of interconnected fibers.

Same as with Spun bound Geotextiles the irregular fiber pattern can be prone to trapping particles.

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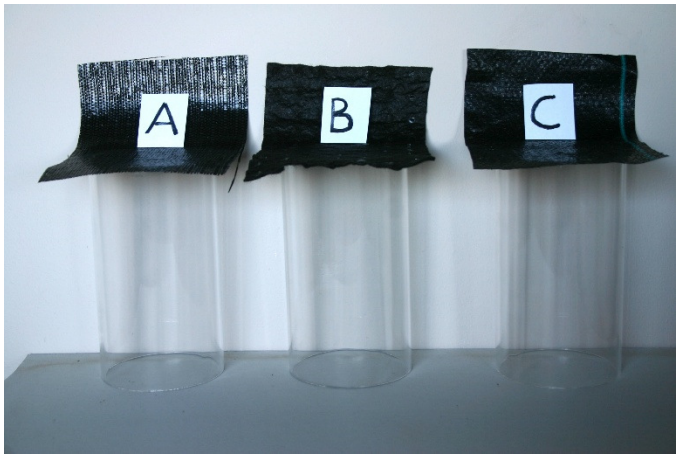
Test method, objectives and result:

ASTM D 4491

Drainage capacity is the amount of water that can pass through the fibers of a Geotextile and is indicated in liters per minute for a given area (mostly indicated as l/minute/m²) in accordance to ASTM D 4491.

ASTM D 4491 describes a Falling Head Test as a procedure to determine the permittivity of Geotextiles. In a Falling Head Test a Column of water is allowed to flow through a Geotextile where readings of head change versus time are taken.

BC Green Roof has conducted 3 tests for you in order to show how Geotextiles behave and how permittivity changes when conditions change.



3 test cylinders each with a commonly used Geotextile affixed

We subjected 3 commonly used Geotextiles to several conditions in order to illustrate how an application can influence its drainage capacity. The different Geotextiles were affixed to clear Lexan cylinders with an inside surface area of 69.5 cm².

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TEST 1:

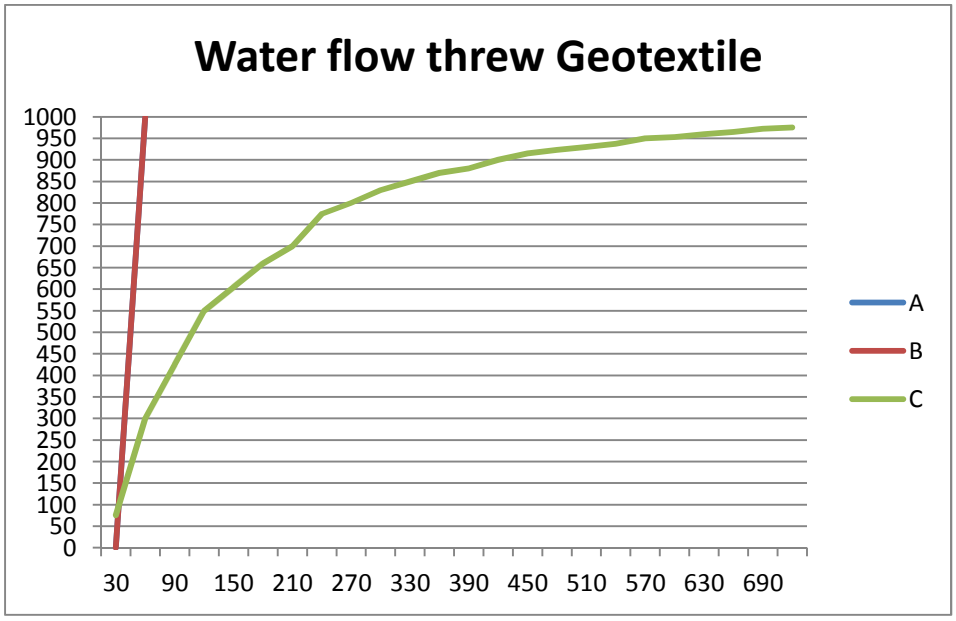
Objective: to visualize how permittivity of Geotextiles behaves as time passes and head pressure reduces.

Proceedings:

In the first test each type of Geotextile (A, B and C) and its cylinder was placed on a drain core and received 1000 ml of water. The water flow draining from the cylinder was monitored and logged. This test was repeated 3 times for all 3 Geotextiles (9 tests in total). Results were divided by 3 to get the average reading of the 3 tests.

Test 1: draining water through Geotextile out of a clear cylinder

In the chart below you find the average of the 3 tests per type of Geotextile (no growing medium). The volume of water drained through the Geotextile is reflected along the vertical line (1000 ml); the time (seconds) to drain the 1000 ml of water is reflected on the horizontal line.



Graph 1) Textiles draining 1000 ml water (143 mm water column) – without growing medium

- Geotextile A drained on average 995 ml in 37 seconds (top left) – (5 ml remained) **- comparable to approx. 231.9 mm rain/minute/m² (231.9 l/minute/m²)**
- Geotextile B drained on average 995 ml in 35 seconds (top left) – (5 ml remained) - **comparable to approx. 246 mm rain/minute/m² (246 l/minute/m²)**
- Geotextile C drained on average 800 ml in 4 minutes and 5 seconds with the remaining 200 ml taking progressively longer as the head pressure became less. 12 minutes where needed to drain 975 ml (25 ml remained) **comparable to approx. 11.6 mm rain/minute/m² (11.6 l/minute/m²)**

In this graph Geotextile A and B drain almost identical and therefore the lines lay on top of one another.

Remarks on the results:

- Geotextile A has a drainage capacity of 36% of its marketed capacity;
- Geotextile B has a drainage capacity of 4.3% of its marketed capacity;
- Geotextile C only has a drainage capacity of 16% compared to its marketed capacity!

TEST 2:

Objective: to visualize the drainage capacity of Geotextiles at the moment or shortly after growing medium has been installed on top of the Geotextile

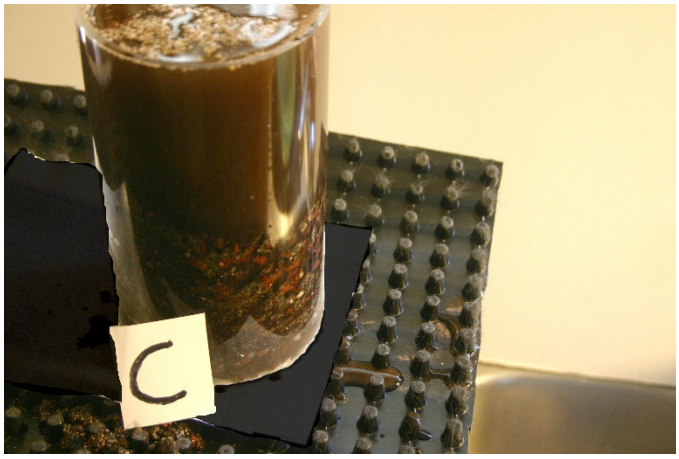
Proceedings:

In test 2 the very same cylinders with Geotextile were filled with 100 mm of growing medium. The growing medium was compacted and topped off back to 100 mm. The test cylinders were soaked with water for 24 hours and after that it was allowed to drain for 24 hours in order to receive a saturated state.

After receiving a saturated state each test cylinder was exposed to a falling head test where 650 ml of water had to pass through the growing medium and Geotextile filter.

The water flow draining from the cylinder was monitored and logged. This test was repeated 3 times for all 3 Geotextiles (9 tests in total). Results were divided by 3 to get the average reading of the 3 tests.

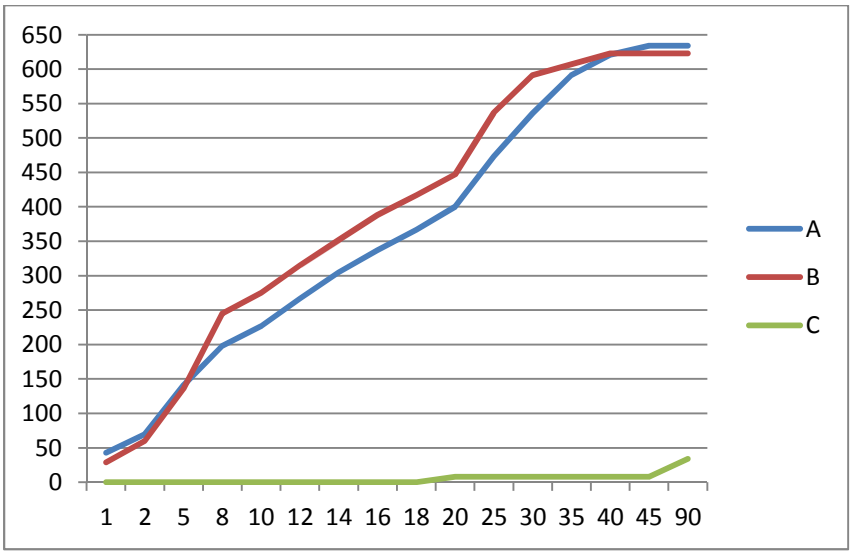
Test 2: Draining water through Geotextiles in a Green Roof application



Geotextile C in test cylinder filled with 100 mm of growing medium and 650 ml of water

In test 2 we show how project conditions vary from lab conditions (clear empty cylinders with Geotextiles vs Geotextiles build in a Green Roof).

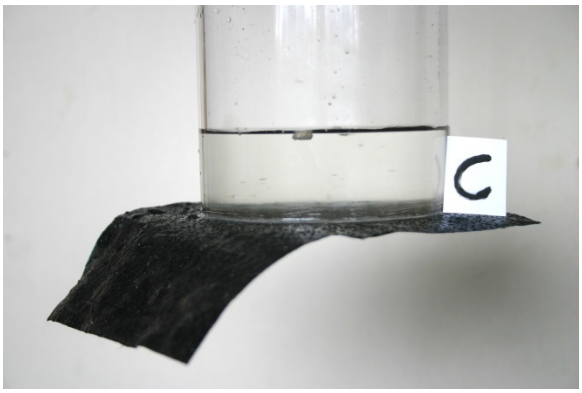
The volume of water drained through the Geotextile is reflected along the vertical line, the time (minutes) to drain the 650 ml of water is reflected on the horizontal line.



Graph 2) Geotextiles draining 650 ml through 100 mm of growing medium.

- Geotextile A drained on average 634 ml in 45 minutes – (16 ml remained) - **comparable to approx. 2.02 mm rain/m/m² (2.02 l/minute/m²)**
- Geotextile B drained on average 623 ml in 40 minutes – (27 ml remained) - **comparable to approx. 2.23 mm rain/m/m² (2.23 l/minute/m²)**
- Geotextile C drained hardly anything; it drained only 8 ml at 18minutes with another 24 ml at 90 minutes into the test. In all 3 tests for Geotextile C the cylinder was allowed 24 hours in total to drain and give data, however, no more water was released after 90 minutes in all 3 tests.

Clearly visible is that as the head pressure progressively reduces itself it takes longer to drain a volume of water. Geotextile C clogged up at each test and was no longer included in test 3.



Geotextile C <u>after preforming test 2</u> and growing medium was removed.
This Geotextile clogged and did not release any more water.

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TEST 3:

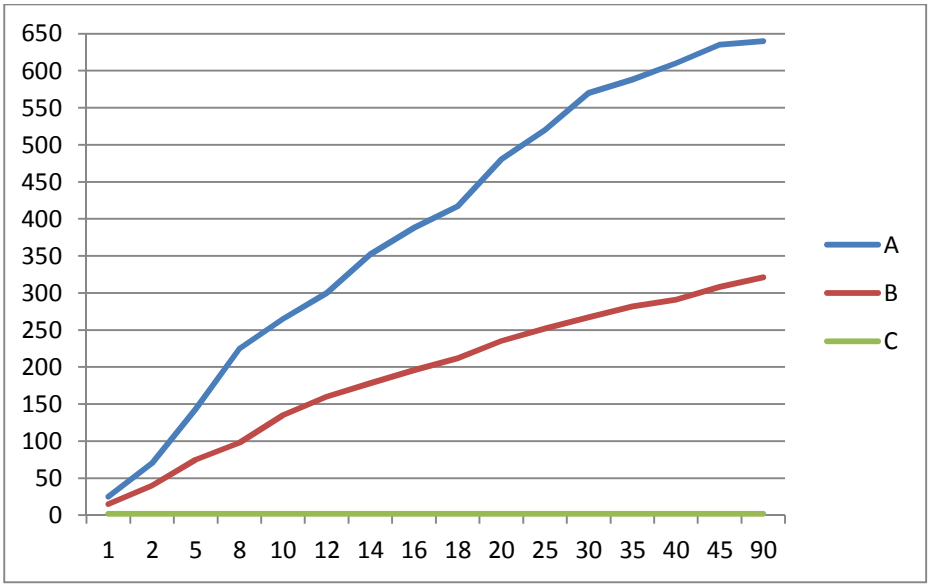
Objective: to visualize the effect long term exposure and settling of growing medium has to the drainage performance of Geotextiles.

Proceedings:

In test 3 we used the setup from test 2 after test 2 was finished. After test 2 each cylinder received 30 times 200 ml of water over duration of 30 days. In total, before proceeding gathering data from test 3, the cylinders and Geotextiles were exposed to 6 liters of water draining through them received 200 ml repeated 30 x before performing another full test with 650 ml. Given the diameter of our cylinders these 6 L that passed through before conducting test 3 equals 86.3 mm of rain (1/7 of the annual rainfall in Victoria BC)

Geotextile C was not exposed to test 3 as it each time clogged during test 2.

The volume of water drained through the Geotextile is reflected along the vertical line, the time (minutes) to drain the 650 ml of water is reflected on the horizontal line.



Graph 3) Draining water through Geotextiles while build in a Green Roof, prolonged water exposure

Geotextile A and B draining 650 ml water threw 100 mm of growing medium after receiving 6 liter of water:

- Geotextile A drained on average 635 ml in 45 minutes (10 ml remained) - **comparable to approx. 2.02 mm rain/m/m² (2.02 l/minute/m²)**
- Geotextile B drained on average 308 ml over the course of 45 minutes (the remainder drained off in the flowing 48 hours with 98 ml remaining after that) **Geotextile B performance at 45 minutes comparable to 0.98 mm rain/minute/m² (2.23 l/minute/m²).**

As you can see in Graph 3 compared to Graph 2, Geotextile B shifted in drainage capacity in the course of 90 minutes, probable reason for this was the fact that we found fine particles of growing medium trapped in the fibers of Geotextile B.

The average flow within the time frame has stabilized when comparing the flow between Graphs. 2 and 3, peak flow at the start, and the stagnated flow as the head pressure reduced.

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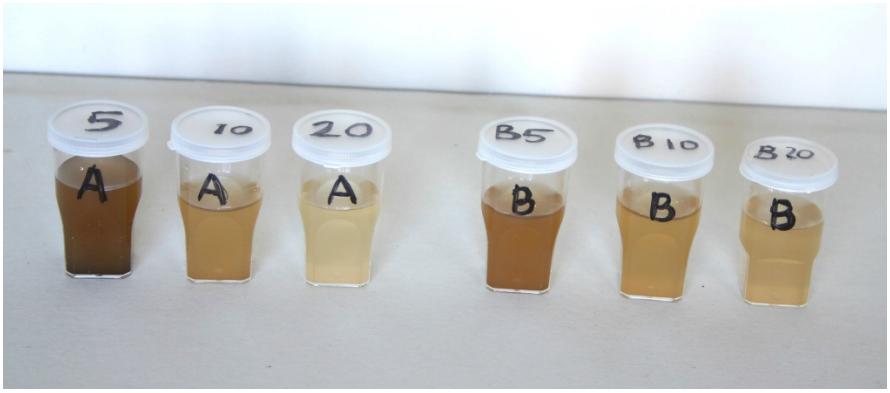
Are Geotextiles equal?

Looking at the Graphics of test 1, 2 and 3 you can see that not all Geotextiles are equal, and not all Geotextiles perform the same under conditions similar to a Green Roof installation.

Looking at the residue of Test 1 (drained water) as well as the Geotextiles after Test 2 it gives insight in what is happening.



Water samples of Geotextile A and B <u>from Test 1</u>
samples taken at 5, 10 and 20 minutes

The water samples above show that vial A5 shows the darkest mix of water with minor residue of fine particles progressively becoming cleaner as particles were released from the growing medium (vial A5 to A20)

Sample A5 shows a slight mix of fine and more course particles that passed through the Geotextile. Note the residue on the bottom of the vial.

Comparing sample A5 with B5 you notice that less particles have passed through Geotextile B. Particularly more course particles are visible on the bottom of vial A5.

The larger particles that passed through Geotextile A (Vial A5) into the drain core were flushed out. With Geotextile B on the other hand these larger particles deposited themselves in the irregular openings of Geotextile B (B5). These particles have left the growing medium of Test 2 in which Geotextile A acts as a natural filter (particles settled in place).

<u>Conclusion/suggestions:</u>

Given the results we suggest designers and engineers to consider an additional ballast in the range of 30 kg/m² that is in place to cover the time it takes to drain off accumulated water in case of a 40mm/5 minute precipitation **(probability 20% in a given year (once in 5 years).**

Better would be to consider added ballast in the range of 50 kg/m² peak, at a precipitation of 60mm/5 minutes **(probability 2% in a given year (once in 50 years).**

These suggestions are based on the results of Test 2A where the Geotextile shows capable of draining around 2 ml/minute/m².

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