Sub-Project P3.1: Development of hybrid biofilters for dual stormwater and groundwater treatment

Summary Report Third Year

Submitted to
Keren Kayemet LeIsrael

by

A. Brenner, H. Cohen, O. Gradus, O. Koren, S. Shandalov, Y. Zinger*

Unit of Environmental Engineering, Faculty of Engineering Sciences, Ben-Gurion University of the Negev, Beer-Sheva;
****The Center for Water Sensitive Cities in Israel***

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Abstract

This report summarizes experiments done during the third year of study. During this year, the task of summer operation (remediation of nitrate-contaminated groundwater by biological denitrification) was completed. In this regard, two columns (generation II, according to Australian experience) were run with two alternative carbon sources, raw cotton and wood chips mixed with pea straw. These columns have been operated for the treatment of synthetic mixtures simulating nitrate-contaminated groundwater (having nitrate concentration of 100 mg/L). During this stage, plants (*Vetiver*) were added on top of the columns to test the effect of vegetation. The results obtained during several months of continuous operation, indicate efficient nitrate removal, and low accumulation of nitrite and TOC. In addition, seven new columns were operated for the treatment of stormwater (winter configuration). A synthetic mixture for the simulation of Israeli stormwater (especially organic matter and nutrients) was used, based on the data collected by the two other research groups (Technion and Hebrew University) in Kfar-Saba area. These columns were operated with gradually increasing loads, starting with 1 liter twice a week and ending with 15 liters once a week. Three plants were tested so far for four columns. The results obtained demonstrate complete nitrification in all columns, complete removal of phosphate under low hydraulic loads, and partial removal of nitrate and organic matter.

1. Introduction

This report summarizes the fourth stage of investigation of biofiltration of nitrate-contaminated groundwater, according to the research plan. The first stage (during the first year) consisted on columns generation I with two alternative media (tuff and plastic beads) and with cotton as a solid carbon source. Based on first year results, further stages of denitrification experiments were done using new improved biofilter columns (Generation II), which were designed and constructed according to the Australian experience (the height and internal composition of the filter media layers). During the second year, two alternative solid carbon sources were tested: cotton vs. wood chips, both mixed with pea straw. In stage two and stage three (during the second year of study), for the same columns configuration, two hydraulic loads were tested. In the fourth stage (during the third year), plants were added to the columns.

According to the research program, third year tasks included also treatment of stormwater (winter configuration). For this purpose, seven new columns were assembled. The columns included two types, which differ in height, in order to test Israeli applications, which may be limited by a shallow infrastructure of water and sewage pipes. A synthetic mixture for the simulation of Israeli stormwater (especially organic matter and nutrients) was used, based on the data collected by the two other research groups (Technion and Hebrew University) in Kfar-saba area. These columns were operated with gradually increased loads, starting with 1 liter twice a week and ending with 15 liters once a week. Some of the columns were planted with three different plants to test vegetation effect.

In the fourth year of study it is planned to apply the hybrid concept by operation of a large set of biofiltration columns with alternating conditions of winter and summer operation (as done separately so far).

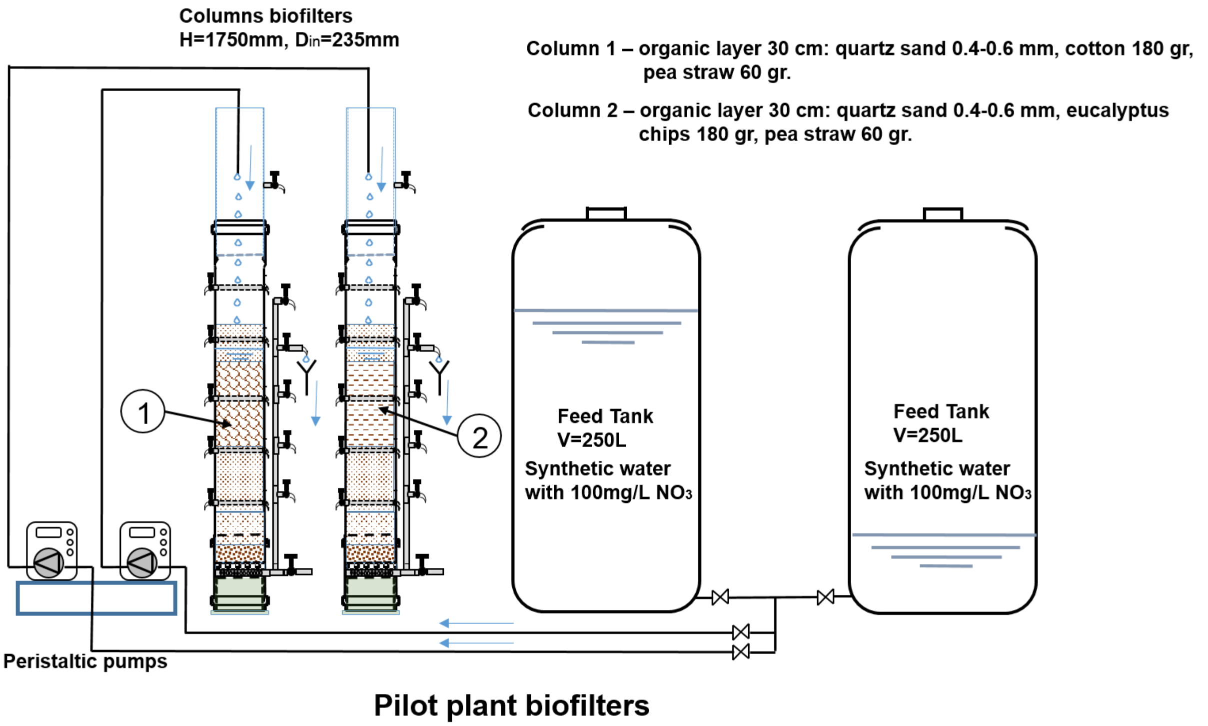
2. Materials and Methods

2.1 – Stage IV of denitrification experiments in biofilters with plants

As was explained previously, this was the final stage of denitrification study based on previous results and conclusions (detailed in previous reports). For this experimental stage, two columns were established according to the Australien design concept, shown in figures 1 and 2. Each column built of PVC has height of 121 cm and diameter of 23.5 cm. Along the column there are 5 ports for sampling. The bottom layer of the column was filled with 3-5 mm basalt sumsum (10 cm height) in order to establish a solid mechanical support for the layers above. These were composed of quartz sand in three layers: bottom 2.5-3.5 mm (7 cm height), middle 0.8-1.5 mm (8 cm height), and a top layer of 0.4-0.6 mm (45 cm height). Each column has a drainage outlet at the bottom connected to a solid pipe up the column, which can control various levels of column saturation (to form an anoxic zone for denitrification). For these experiments, the height of the saturation zone was 70 cm. On top of the column, a 54 cm transparent Perspex column could be connected to support growing plants. The top 30 cm of the smallest sand layer was mixed with two types of solid carbon sources. Two columns were tested: one with cotton and the other with wood-chips. Both sources were mixed with pea-straw (mass ratio 3:1). On top of the columns, *Vetiver* plants were planted in order to test the effect of vegetation (see figure 3).

Above the saturated zone, 30 cm of the filter included only quartz sand (0.4-0.6 mm). This layer served for consumption of oxygen in order to reduce its concentration before entering the saturated zone (to prevent aerobic degradation of the carbon source). Two 250-liter tanks were filled with a nitrate solution (KNO_3) to form concentration of 100 mg/L in tap water. This solution served as the feed for the columns, pumped continuously by

Masterflex L/S compact drive peristaltic pumps. The hydraulic load applied was 36 mm/h (38 L/d per column).



ative carbon sources.

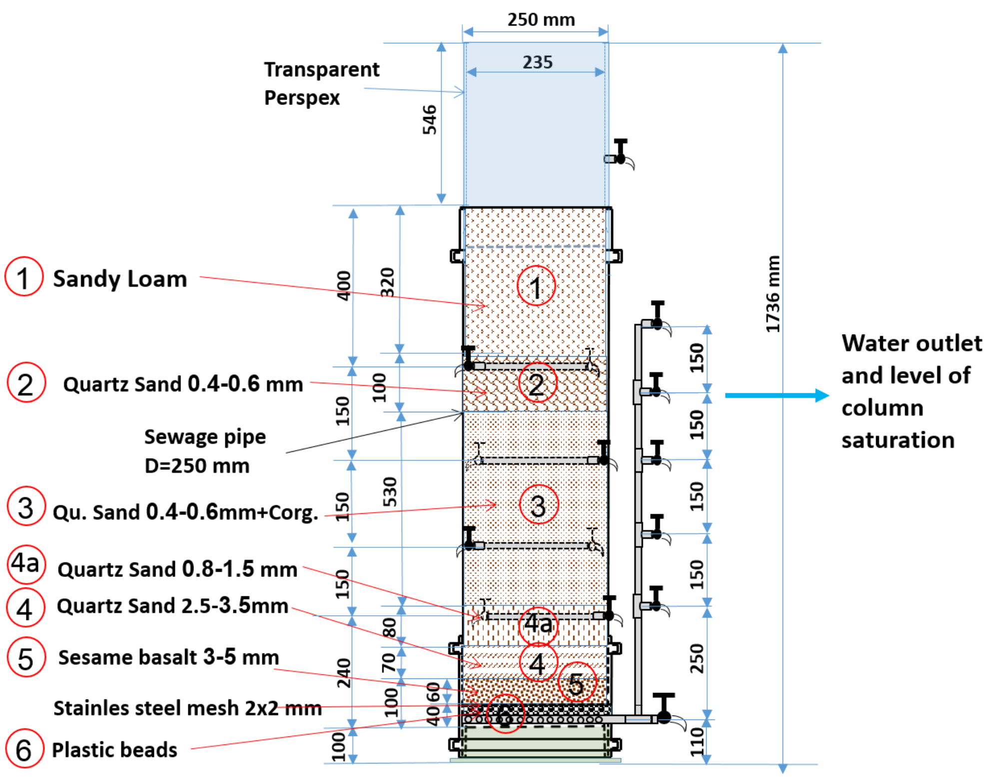


Figure 2. Internal structure of the experimental columns used for nitrate removal by denitrification.

Figure 3. Picture of the experimental system for the comparison of two alternative carbon sources with presence of vegetation (*Vetiver*).

2.2 – Operation of biofilter-columns for the simulation of stormwater treatment

For this purpose, seven additional columns were constructed and operated. Due to the low nitrogen content of typical Israeli stormwater (less than 5 mgN/L) as obtained in the sampling tasks of the other groups, the biofilters were designed to be capable of removing TKN by aerobic nitrification. It is believed that it is not crucial to reduce the resulting nitrate (<5 mgN/L) by incorporation of denitrification in the biofilter design, since this level is far below the natural background of groundwater, and below the disposal standards into rivers.

It is therefore not essential to apply a large (deep) saturated zone within the biofilter enriched with carbon source since leaching of TOC (carbon source hydrolysis) is more problematic than the release of low-levels nitrate. As demonstrated in previous stages, excess carbon leaching (being itself a problem) might cause sulfate reduction and formation of sulfides in groundwater. It might also lead to other problems related to the formation of anaerobic conditions (as the manganese release phenomenon observed in Tel-Aviv soil-aquifer treatment).

Based on these assumptions, the columns were designed to have a minimal bottom saturated zone of 10 (short column) and 25 cm (long column) only and no use of carbon source in all columns. Another difference from the Australian practice was the construction of 5 of the 7 columns used to simulate stormwater treatment (winter phase) in a shorter height and modified structure, as shown in figure 4. This was done in order to test Israeli applications, which may be limited by a shallow infrastructure of water and sewage pipes.

Two other columns had the same internal composition as the columns served for the simulation of denitrification in the first year (see figure 2). Since there were problems to find a proper sandy-loam (having a sufficient hydraulic conductivity), one of the sources found (sandy-loam) was mixed with quartz sand (0.4-0.6 mm) to form upper layer bed (40 cm height) having an hydraulic conductivity of 550 mm/h (35% loam). This was done by preliminary testing of hydraulic conductivities of various proportions of loam and sand as illustrated in figure 5.

The experiments were done using a synthetic mixture for the simulation of a typical Israeli stormwater. We used the data collected by the Technion and Hebrew University groups in Kfar-Saba area, incorporating 25 sub-basins, which include residential area, industrial zone, and paved roads. Quantity of rain in each event (mm) and duration of dry days before each event, are given in table 1.

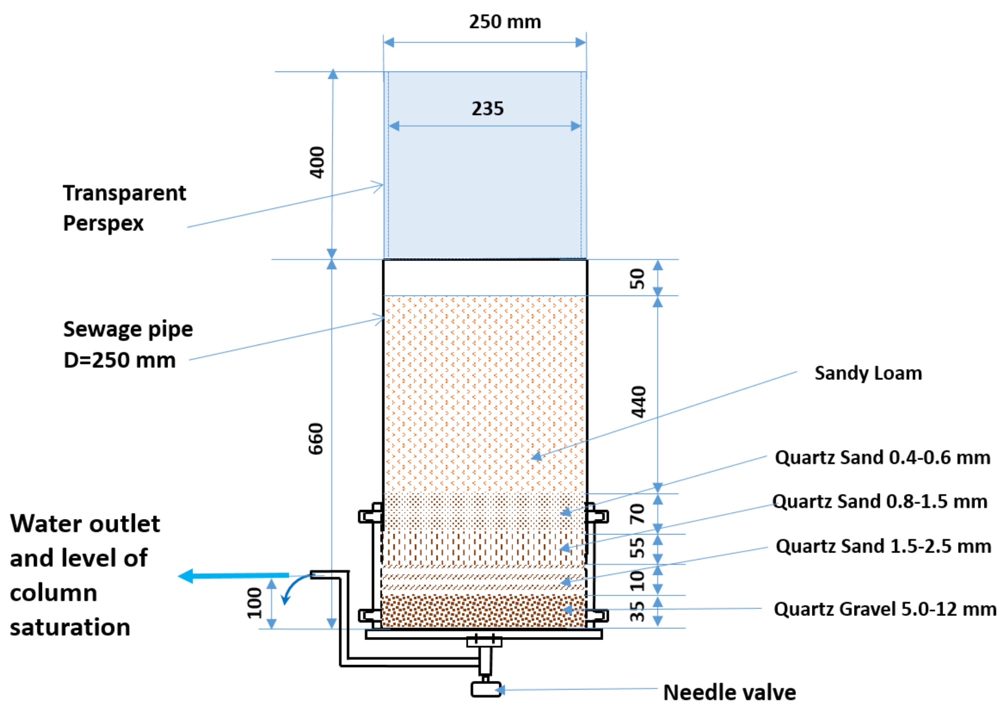


Figure 4. Structure of the short columns served for simulation of stormwater treatment.

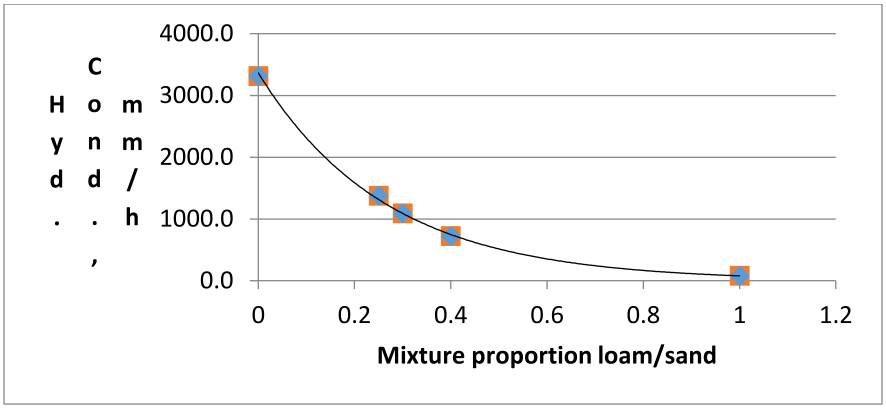


Figure 5. Hydraulic conductivity of various proportions of Loam and Quartz sand.

Typical average mean concentration (EMC) of contaminants for the whole area is given in table 2. The synthetic solution, which served for the experiments, was prepared by mixing DDW (80%) and tap water (20%). Various salts were added to form typical concentrations of organic matter, nitrogen, phosphorus, and various minerals (sodium, chloride, calcium, and electrical conductivity). A humic acid was selected to present the natural organic matter characterizing surface water. It is relatively non-biodegradable organic substance, but it tends to adsorb to soil. No suspended solids and metals were added at this stage.

Table 1. Typical characteristics of rain events in east Kfar-Saba basin (winter 2016-2017).

Number of dry days before each event	Quntity of rain in each event (mm)
12	10.5
10	11.63
3	42.15
10.5	63
15.5	21.63
2.5	38.5
11	40.92
13	34.42
21	14.83
7	14.08
14.75	11.83
First Flash	27.44
11	31.5
4	16.76
5	52.32
2	57.4

Average	9.48	30.56
Standard Deviation	5.32	16.73
Median	10.25	29.47

Table 2. Typical composition of stormwater in east Kfar-Saba basin (winter 2016-2017).

Pollutant	EMC whole basin, mg/L
TSS	356.169
EC	207.473 [μS/cm]
TKN	4.000
COD	66.000
P	1.146
Cr	0.179
Cu	0.039
Ti	0.925
Zn	0.183
Mn	0.315
Al	26.872
Ba	0.100
Ca	38.774
K	6.026
Mg	12.279
Na	13.652
S	3.740

Table 3. Composition of synthetic solution for the simulation of stormwater composition.

	Solution components				Design, mg/L
	NH4Cl	K2HPO4	NaHCO3	Humic acid	Solute: 0.8DDW+0.2TW
	(ppm)	(ppm)	(ppm)	(ppm)	
Concentration	20	10	50	10	
TOC	-	-	-	5	5
N	5.24	-	-	-	5
K	-	4.49	-	-	5
P	-	1.77	-	-	2
Cl	13.26	-	-	-	20
Na	-	-	13.70	5	20
pH	5.23		6.81		7
EC [μS/cm]	155.0				150
Alkalinity	-	-	29.27 mg/L as CaCO3	-	30

The main initial purpose was to follow the transformations of organic matter and nutrients (nitrogen and phosphorus forms) within the columns. The composition of the synthetic mixture serving for first phase simulation is given in table 3.

For these experiments, three types of plants were used: *Agapanthus, Tolbaghia, and Vetiver*. Layout of the experimental array in a new experimental station (on the roof of our new building) is shown in figure 6 and the typical plants in figure 7. Three columns were operated with no plants (two long columns and one of the short columns) in order to examine bacterial activity within the column with no plant effect. One of the long column was seeded with biomass from a near-by WWTP.

Figure 6. Layout of the experimental array for the simulation of stormwater treatment.

Figure 7. The plants selected for the first stage stormwater treatment experiments (from left: *Agapanthus, Tolbaghia, and two Vetiver*s).

3. Results and discussion

3.1 – Testing denitrification in biofilters planted with Vetiver

According to the procedure described in section 2.1, two columns were operated to simulate bioremediation of nitrate-contaminated groundwater (initial concentration 100 mg/L), under continuous flow, hydraulic load of 36 mm/h, and use of *Vetiver* plants on top of the columns. Two carbon sources were tested, cotton vs. wood-chips. Pea-straw was also added to each column as described earlier. At the end of this stage the hydraulic conductivity of the two columns were measured according to the Australian practice. The values obtained are 775 and 1018 mm/h, for the cotton and wood-chips columns, respectively.

3.1.1 – Nitrate removal

This fourth stage during the third year of the study was applied for 100 days. During this stage, *Vetiver* plants after acclimation of several weeks in external vessels were added on top of the columns. These plants proved to be resistant to hot weather and could flourish well under continuous wetting. The plants adjusted and developed very well, but no change in process performance was observed compared to the previous stages (described in previous reports). Chronological changes of nitrate concentrations in columns outlets are shown in figure 8 showing a better performance of the cotton-based column.

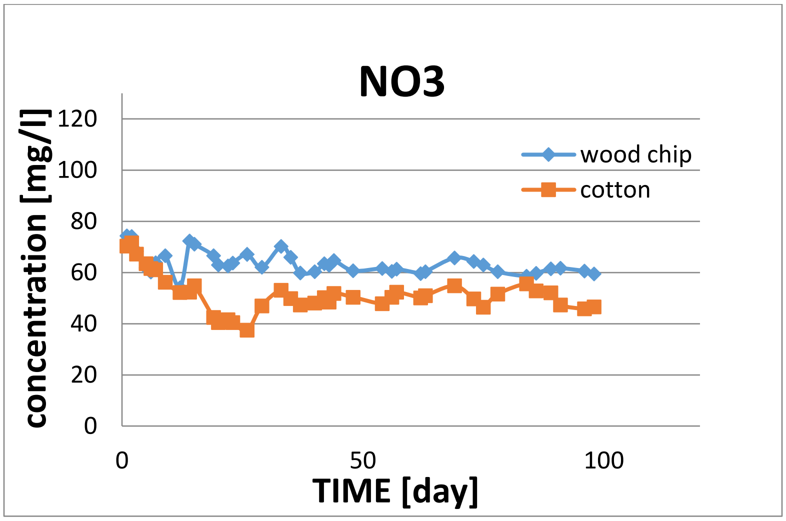


Figure 8. Columns nitrate outlet concentrations in the fourth stage of the denitrification study for the cotton and wood-chips systems.

3.1.2 – Nitrite formation

The synthetic solution that served for the denitrification experiments did not contain nitrite. Nitrite is actually an intermediate compound formed frequently during denitrification. It might accumulate due to some factors such as C/N ratio, hydraulic load, and oxygen inhibition. These parameters are more difficult to control in a deep biofilter than in a conventional reactor. As happened in the first year (polyethylene beads and tuff columns) nitrite might accumulate under certain conditions, when high levels of nitrate are treated. Nitrite is much more problematic than nitrate concerning the Metha-hemoglobinemia phenomenon. Consequently, in some countries drinking water quality standards are much more stringent for nitrite. Therefore, it was crucial to monitor nitrite formation during all experiments related to denitrification of high-nitrate concentrations. Figure 9 shows very low levels of nitrite during the fourth phase, indicating partial removal of nitrate (figure 8) but complete reduction of nitrite.

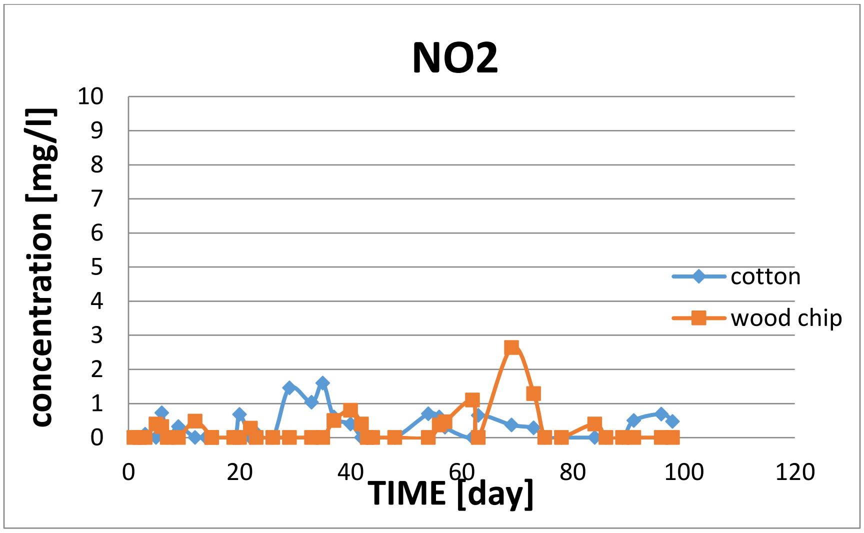


Figure 9. Nitrite residuals in the fourth stage of the denitrification study for the cotton and wood-chips columns.

3.1.3 – Fate of organic matter

The synthetic solution, which served for the experiments, did not included any source of organic matter. The source of excess TOC in the biofilter outlet stems from hydrolysis of the carbon sources put within the columns. During the first and second stages due to the various events observed (biofilter clogging, tracer experiment, backwash) TOC levels were relatively high and not stable. Once biomass level and carbon source content adjusted, the TOC residual became stable and lower than 4 mg/L, during stages III and IV, as evidenced in figure 10.

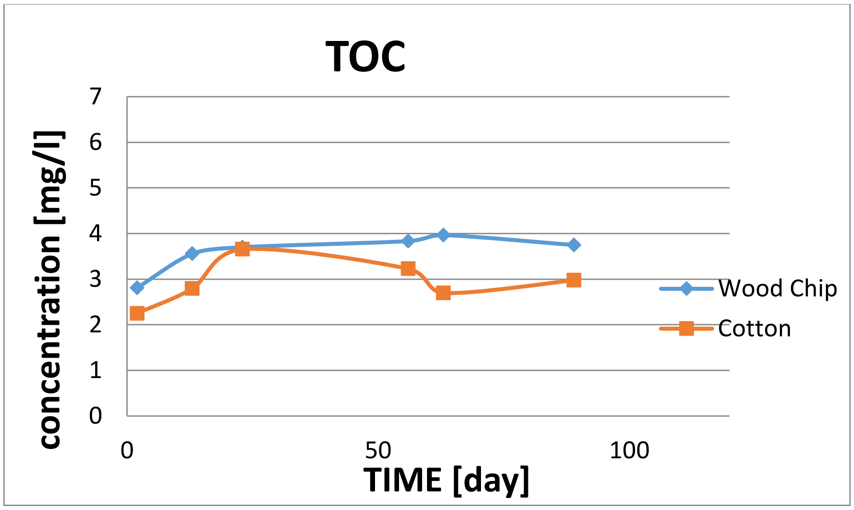


Figure 10. Residual TOC in the fourth stage of the denitrification study for the cotton and wood-chips columns.

3.2 – Operation of biofilter-columns for the simulation of stormwater treatment

As described in section 2.2, 7 columns were constructed to simulate stormwater treatment (winter configuration). The columns were marked as follows:

1. Australian mode column (long – see Figure 2) with no vegetation;
2. Australian mode column with no vegetation and with a seed of acclimated bacteria;
3. Short column (see Figure 4) with *Agapanthus*;
4. Short column with *Tulbaghia*;
5. Short column with *Vetiver*;
6. Short column with *Vetiver* (a second identical one);
7. Short column with no vegetation.

The columns were operated in a batch mode based on manual instantaneous irrigation, which was gradually increased in volume, and decreased in frequency. Results of five subsequent periods, tested in the third year of study, are described herein. They include:

A. Daily feed of 1 liter;
B. 2 liters twice a week;
C. 5 liters once a week.
D. 10 liters once a week.
E. 15 liters once a week.

This strategy was selected to gradually load the columns to reach a critical load resulting in columns failure (breakthrough of pollutants). It is also aimed at comparing two types of columns (long and short), and testing the no-saturation & no-addition of carbon source concept and its effect on nutrients and TOC transformations (based on the assumptions presented in section 2.2). The results shown are related to the experiments done during the third year of the research study and reflect gradual acclimation to increasing hydraulic loads and reduced frequency of application.

Figure 11 demonstrates high efficient removal of ammonia, probably due to bacterial nitrification, since this behavior is achieved in columns with and without vegetation. The large aerobic zone applied, enables complete nitrification even with the highest hydraulic load (15 liters once a week). All columns produced effluents with ammonia concentration lower than 0.3 mgN/L (feed concentration is approximately 5 mgN/L). This process results in the formation of nitrate, as shown in figure 12. The theoretical nitrate concentration is expected to be 5 mgN/L. The four columns with vegetation demonstrate lower nitrate concentrations compared to the non-vegetated columns. It is assumed that the plants contribute to the removal of nitrogen by N fixation.

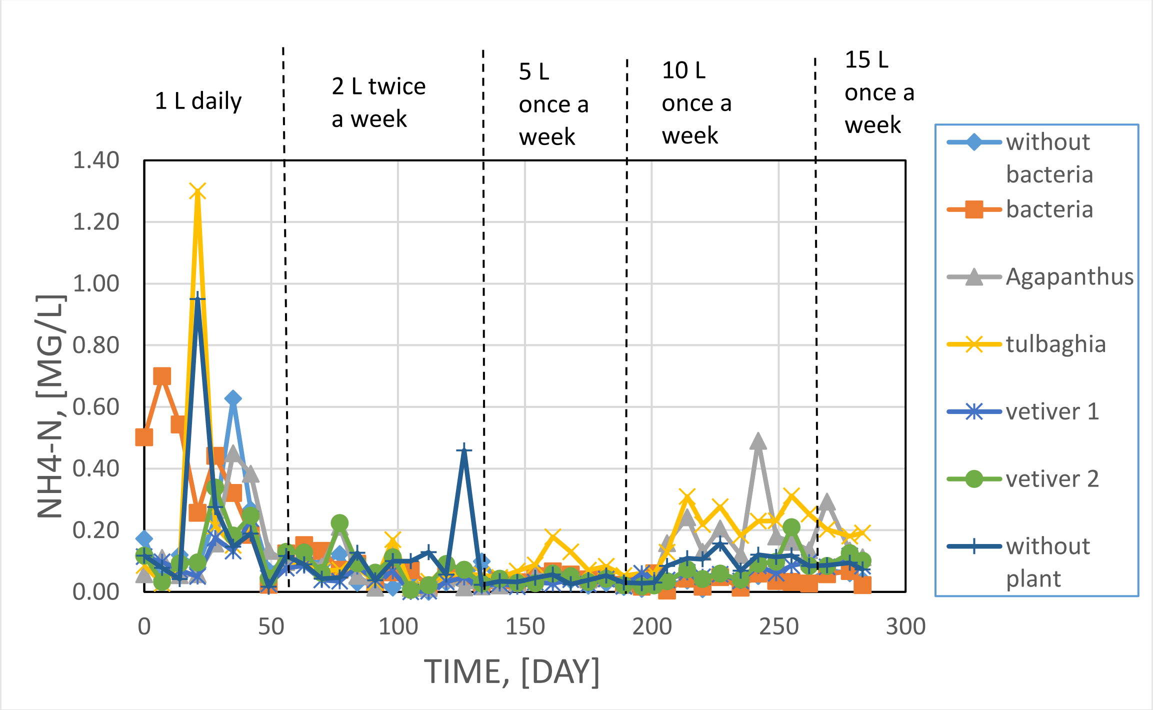


Figure 11. Fate of ammonia during simulation of stormwater treatment.

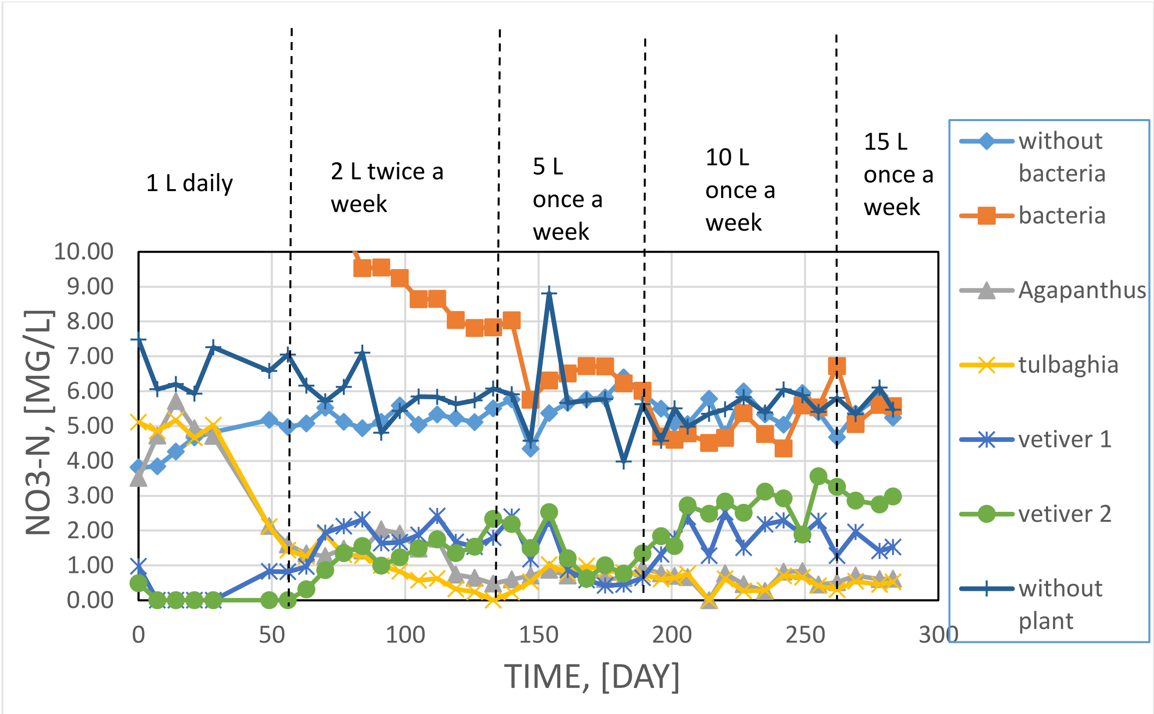


Figure 12. Fate of nitrate during simulation of stormwater treatment.

The column with biomass seed released nitrogen, phosphorous, and TOC probably due to biomass decay. These effects are diminishing with time (see figures 11-15).

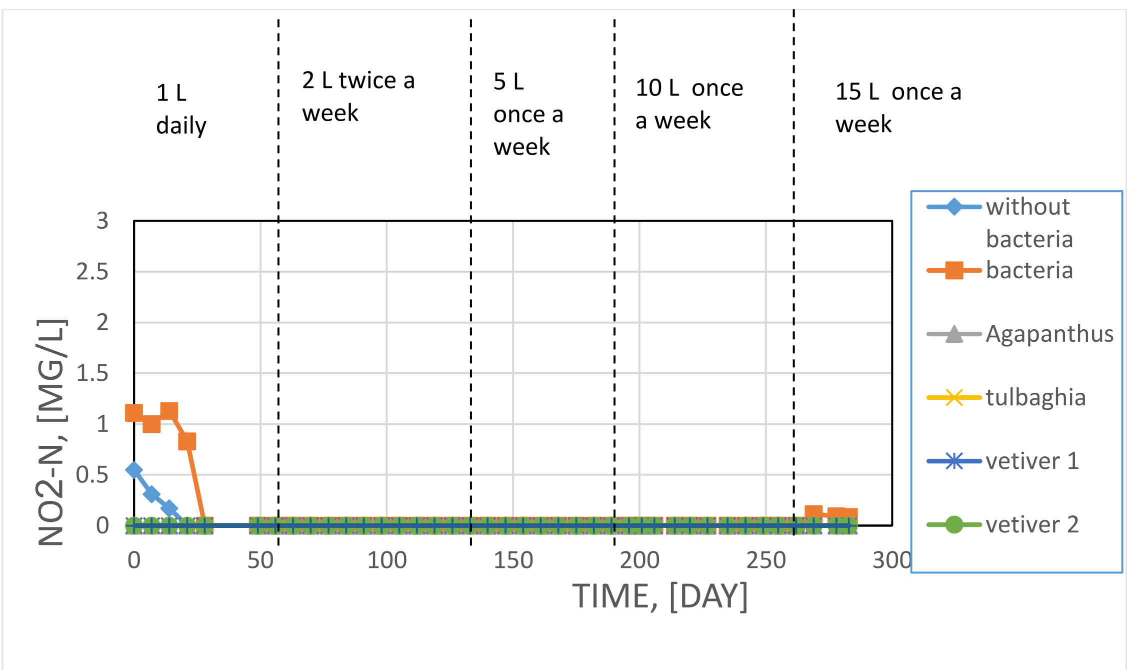


Figure 13. Fate of nitrite during simulation of stormwater treatment.

No nitrite has accumulated so far and there is no effect of the feed application regime (Figure 13). Phosphate removal (probably due to soil sorption) was complete under low loads. However, the removal decreases (breakthrough) under higher loads of 10 and 15 liters per week (Figure 14).

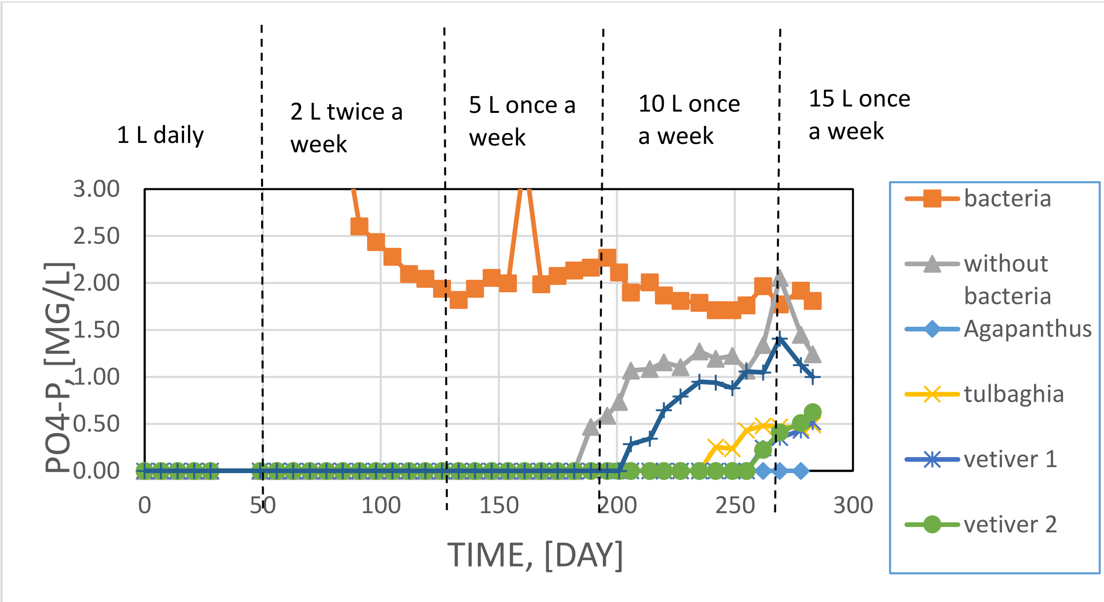


Figure 14. Fate of phosphate during simulation of stormwater treatment.

TOC has been slightly removed, probably by sorption to soil. However, with the increase of water volume applied, effluent TOC is increased (figure 15).

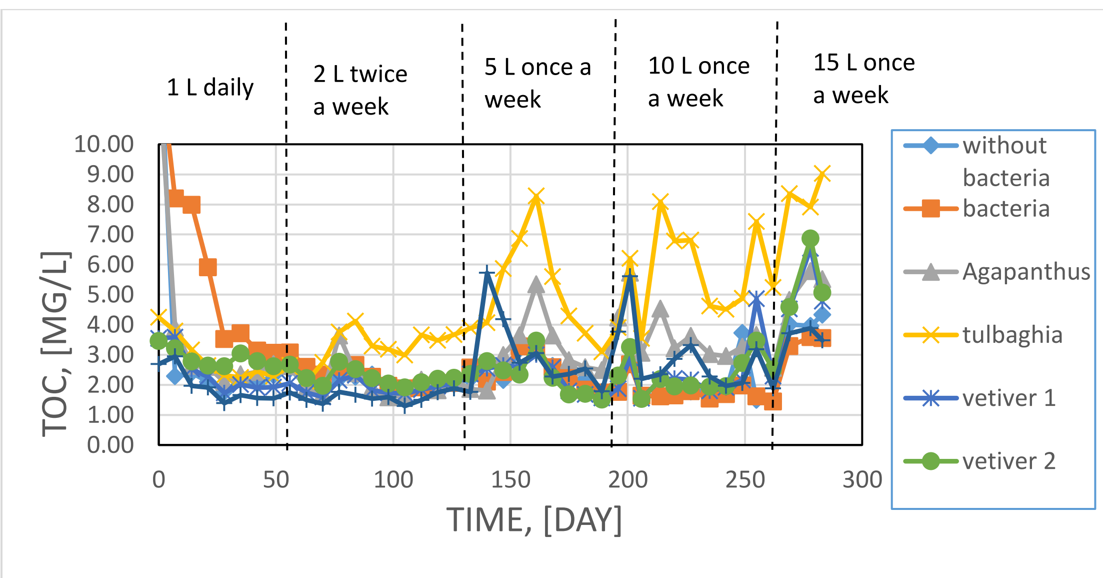


Figure 15. Fate of TOC during simulation of stormwater treatment.

The type of organic compound used for the simulation (humic acid) is relatively non-biodegradable. This compound was selected for the simulation since it is abundant in natural surface water. It is assumed that in real stormwater there are additional organic compounds released from anthropogenic sources. These include soft carbon sources, which may be degraded by natural bacteria.

Turbidity of columns effluents (Figure 16) is relatively high under high hydraulic loads, probably due to washout of tiny soil particles present in column layers. Effluents filtration (0.45 μm laboratory filters) to simulate deep soil filtration, results in significant turbidity removal (Figure 17).

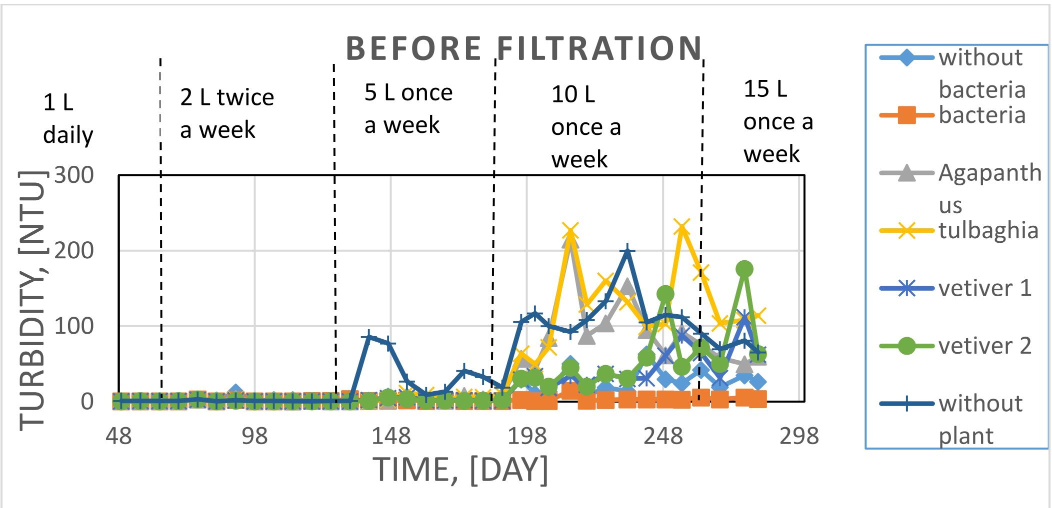


Figure 16. Effluent turbidity during simulation of stormwater treatment.

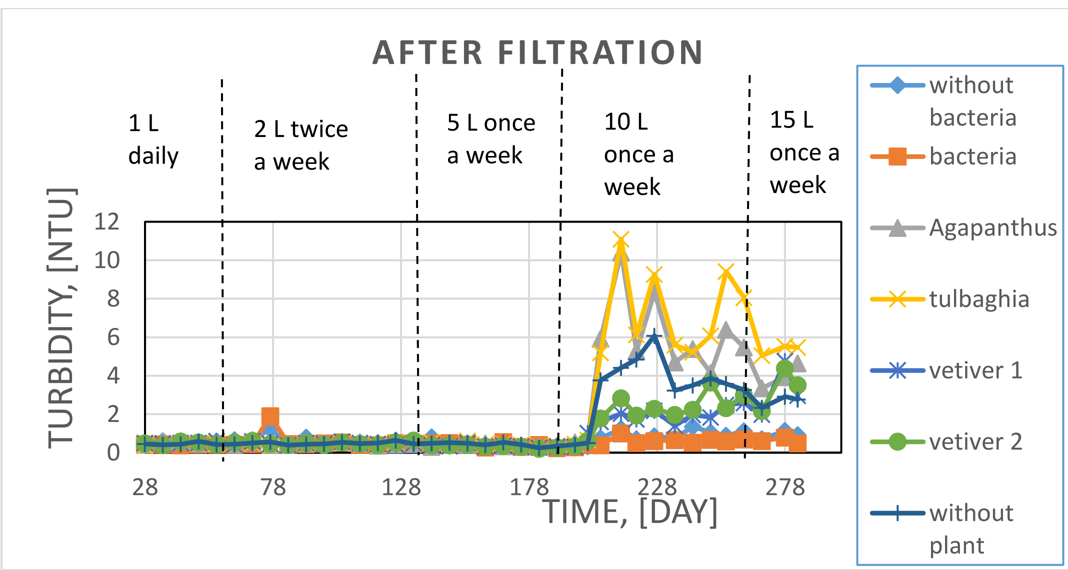


Figure 17. Effluent turbidity after filtration with laboratory 0.45μm filters.

Figure 18 shows total N removal (of all N species) based on inlet and outlet concentrations. However, this measure does not reflect real removal since water is lost due to evaporation and thus cause concentration of outlet values. However, it can be clearly observed that the vegetation contributes to total N removal.

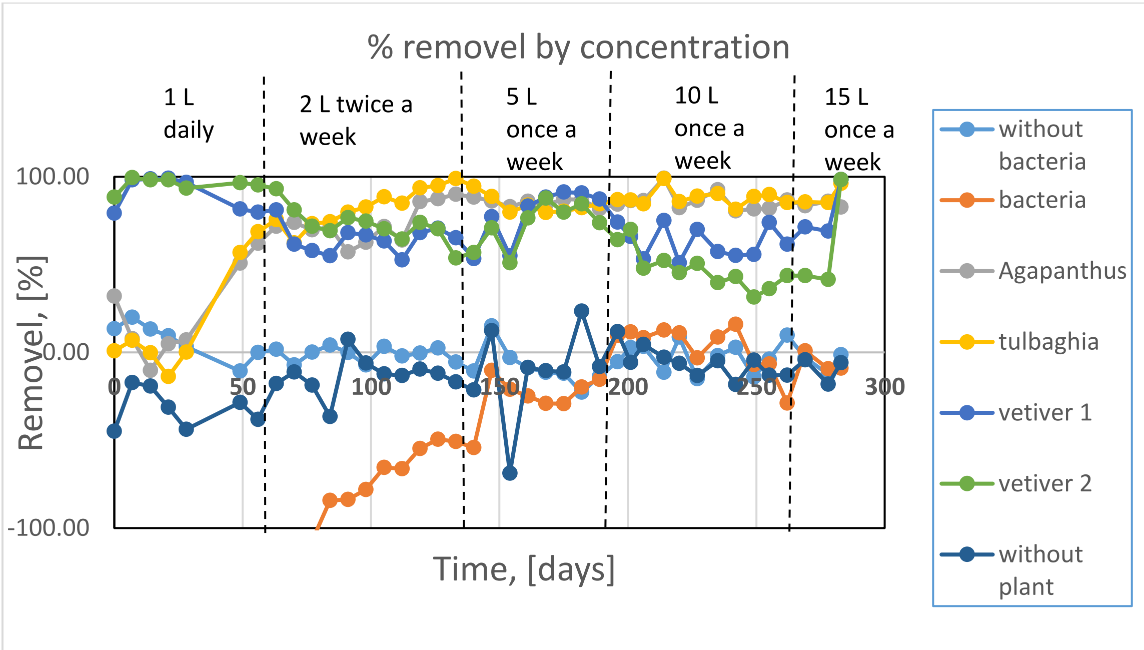


Figure 18. Total N removal percent based on concentration change.

The change in outlet volumes is shown in Figure 19 and the water volumes lost due to evaporation (difference between inlet and outlet volumes) are shown in Figure 20.

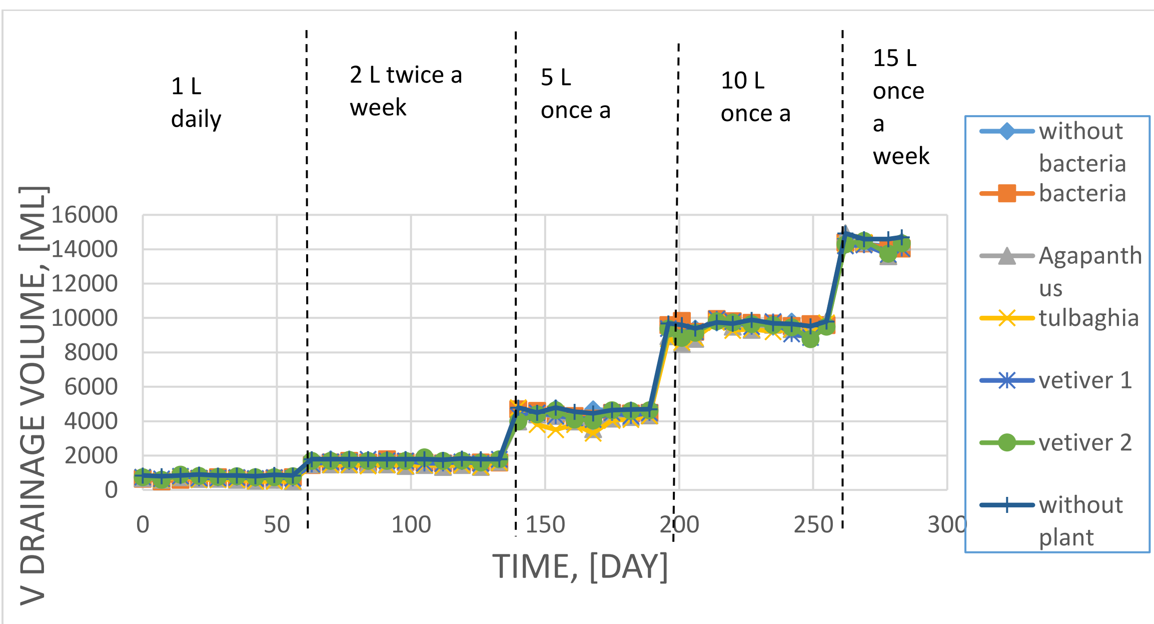


Figure 19. The change in outlet water volumes.

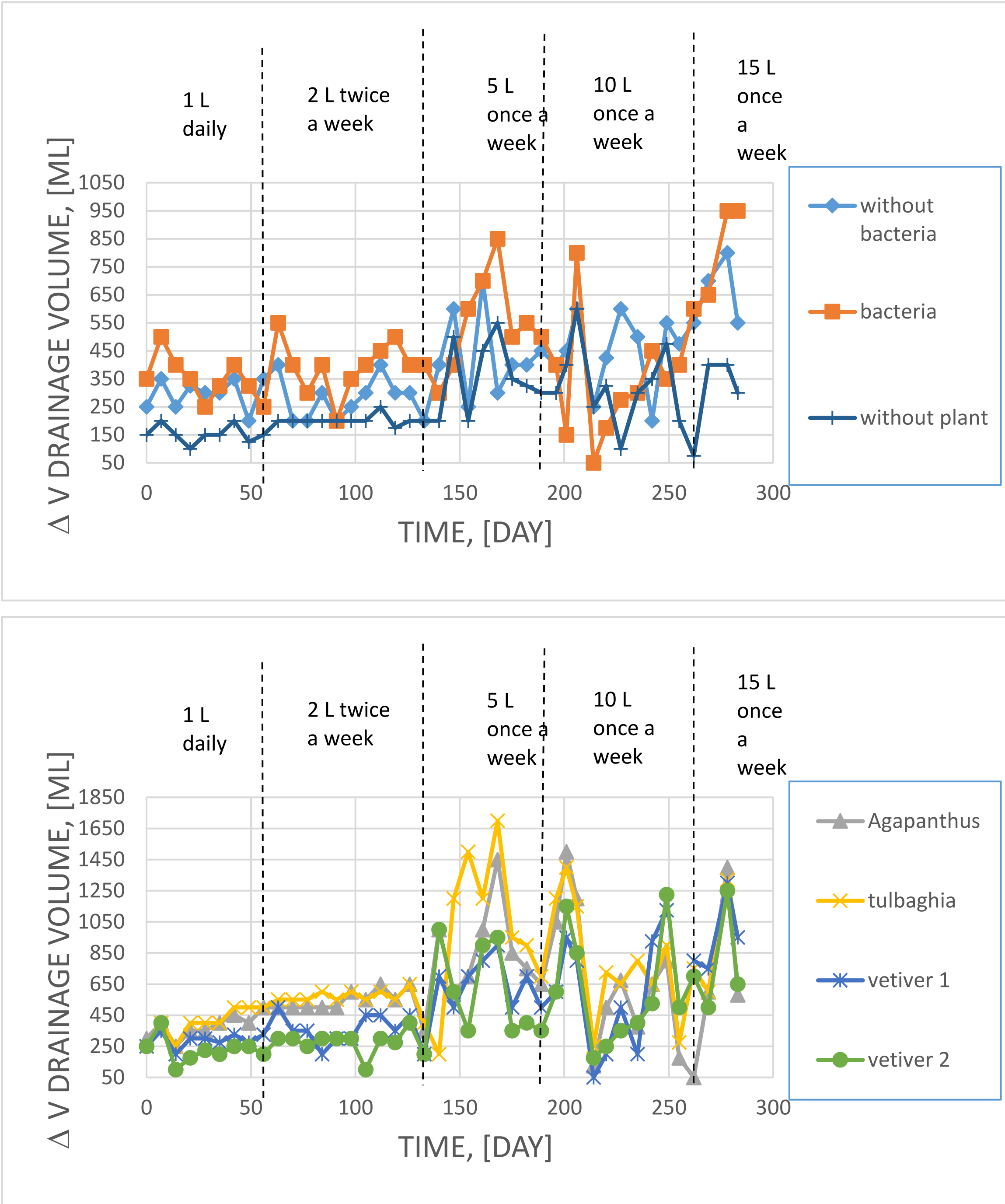


Figure 20. Reduction of columns outlet volumes due to evaporation (upper section columns without plants, bottom section columns with vegetation).

It is therefore possible and more accurate to calculate removal efficiency on basis of contaminants loads and not on basis of their concentrations. Contaminant load is calculated by multiplying water volume and contaminant concentration. These calculations are presented by the two expressions below (C=Concentration; Q=Water volume).

Concentration-based removal rate:

$$\boxed{RRconc = \frac{Cin - Cout}{Cin}}$$

Load-based removal rate

$$\boxed{\mathrm{RRload} = \frac{Qin * Cin - Qout * Cout}{Qin * Cin}}$$

These calculations indicate that the real removal rate of all contaminants is higher by 5-15%, related to the fraction of water lost by evaporation.

Another measure that was done routinely is the velocity of water through the columns based on extent of the time elapsed until first drops appear in the column outlet. This is not the actual Darcy velocity. However, it can indicate trends developed in the columns. As shown in Figure 21, the velocity was gradually decreased and then stabilized with time. This is a typical behavior of such biofilters.

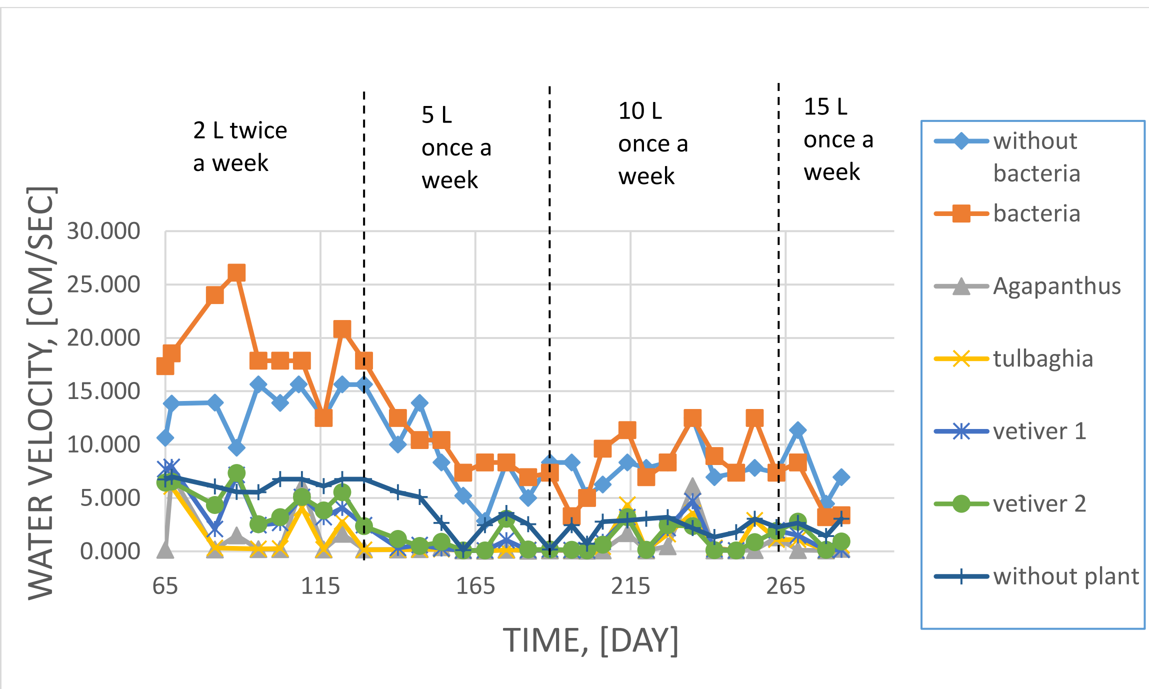


Figure 21. Water infiltration velocity in the columns.

4. Summary and conclusions

Three years of the research study have been completed so far. The study served as a basis for two M.Sc. research theses of Amir Aloni (Generation I denitrification columns) and Hodaya Cohen (Generation II denitrification columns). A third M.Sc. student (Or Gradus) is running the columns for stormwater treatment.

Based on the results so far we think that two types of biofilters should be developed in Israel:

a. A conventional biofilter for stormwater harvesting and treatment, which will be active for this purpose only during the wet season. During the dry season, the biofilter should be maintained by irrigation and serve as an aesthetic green area.
b. A hybrid biofilter, which can be used also for bioremediation of nitrate-polluted groundwater during the summer, in places where there is a near-by well containing high nitrate levels (other options of remediation are also feasible).

In addition, the main conclusions derived during three years of the study are:

- In the mode of bioremediation of nitrate-contaminated groundwater, complete removal of nitrates is not required since the standards of nitrate in drinking water are quite high (45 mg/L in Europe and 70 mg/L in Israel).
- It is also essential not to completely remove nitrate from the system in order to prevent TOC leaching.
- Nitrate removal occurs due to organic matter oxidation. An over reduction of the nitrate by denitrification will cause a faster consumption of the organic matter and shorten the biofilter's operation life.
- After the consumption of NOx, the system might become anaerobic instead of anoxic. In such an environment, sulfate-reducing bacteria (SRB) might prosper, resulting in sulfate reduction and formation of sulfide, which is toxic and constitutes an odor hazard.
- Use of cotton as alternative solid carbon source (in place of the traditional wood-chips) was found to be feasible and efficient.
- Biofilters are typically designed for a hydraulic load of 200-400 mm/h, in order to be able to cope with high instantaneous floods. For the stage of groundwater remediation, the hydraulic load should be based on process kinetic limitations.

Therefore, a lower hydraulic load is expected. In this regard, the maximum application rate for the winter configuration (stormwater treatment) was 15 liters per week for the columns tested (surface area of each column 0.04335 m^2). In the summer mode operation (remediation of nitrate-contaminated groundwater), each column received continuously 40 liters per day (280 liters per week).

- In the summer mode of operation, plants contribution to nitrate removal is negligible compared to bacterial denitrification. Therefore, it is not crucial to use plants on top of the columns in this experimental stage.
- In addition, since groundwater is clear, plants are not crucial (in the experimental stage) since there is no threat of solids accumulation and formation of a "cake" on top of the column.
- In the mode of stormwater treatment (winter configuration), we initially assumed that there is no need to apply denitrification (i.e., addition of carbon source and establishing a large saturated zone). This is due to the high background nitrate levels in groundwater, Israeli drinking water standards for nitrate, and river disposal standards in Israel (requiring less than 10 mgN/L). Therefore, it is not crucial to reduce the nitrate formed by nitrification (<5 mgN/L) by incorporation of denitrification in the biofilter design, since this level is far below the natural background of groundwater, and below the disposal standards. It is therefore not essential to apply a large (deep) saturated zone within the biofilter and install a carbon source since leaching of TOC (carbon source hydrolysis) is more problematic than the release of low-levels nitrate.
- The problematic nitrogen forms that should be removed are organic nitrogen and ammonia. These could be easily removed (as demonstrated) by bacterial nitrification (and perhaps by plant assimilation that may partly remove also nitrates).
- Biofilters with no carbon source and reduced-size saturated zone will be more simple to construct and less costly. Problems of TOC leaching into groundwater (and consequent reactions) will be eliminated. According to the Australian experience, leaching of TOC is increased with increased depth of the saturated

zone. In addition, according to the Australian practice wood-chips are practically added to biofilters to support their activity for 15 years.

- Israeli stormwater composition is quite different from typical Australian stormwater especially concerning suspended solids and metals. It is very difficult to constitute a representative composition (including oil) that will serve for accurate design, based on laboratory simulation.
- Based on the experiments done so far with the columns for treatment of simulated stormwater, no difference was found between long and short columns.
- All columns achieved complete nitrification to levels below 0.3 mg/L for the whole range of water volumes applied.
- Columns with plants achieved higher removal of total N, probably due to plant assimilation.
- Phosphate removal by all columns was complete under low water volumes application, probably due to soil sorption. Increase loads (application of 10 and 15 liters per column) caused phosphate breakthrough.
- The humic acid (which is considered non-biodegradable) added to the feed water was partially removed probably due to soil sorption. Increased load caused breakthrough.
- Under high hydraulic loads (10 and 15 liters per column), high turbidity levels were obtained in columns outlet. It is caused by washout of tiny soil particles. This phenomenon limits direct reuse of the treated stormwater. However, if treated stormwater infiltrate deeper soil layers, the turbidity be removed by gradual filtration.
- It is more accurate to evaluate process efficiency by contaminant load change.

5. Future work for the forth year

Our research group has moved to a new building in BGU campus. A new site for our experiments was constructed on the roof of the building including infrastructure of electricity, water, and drainage (figure 22). A new greenhouse with transparent roof is under design together with some constructional modifications to enable the expected mechanical loads.

Figure 22. The new BGU site for the operation of biofilter systems.

During the next stages of the research study for the fourth year, we will concentrate on stormwater treatment, incorporating the following aspects:

- Testing of columns with and without various plants under various hydraulic loads, coordinated with data obtained from the other groups.
- Testing the hybrid concept by alternating operation of the columns in summer and winter modes.
- Development and testing of a unique approach to control solid organic carbon utilization in summer operation.
- Development of Israeli design guidelines for biofilters.

6. Appendix – detailed experimental plan for the fourth year

For the fourth year of study, a detailed testing program was prepared. It includes various biofilters with different plants, which will be operated in the hybrid mode (alternating feed of nitrate-contaminated water in continuous pumping, and instantaneous feed of simulated stormwater).

קולונות	16,17,18	13,14,15	10,11,12	7,8,9	4,5,6	1,2,3
צמח דומיננטי	כריך פנדולה	כריך אוסטרלי	baumea rubiginosa variegata	מללוייקה סערת שלג	כריך מכחיל	וטיבר
צמח משלים	איריס לואיזיאנה	רייחן הר הקסם	בת קלה אתיופית	טולברגיה	אגפנטוס	
תורם e	**כותנה נטענת**	שבבי עץ	כותנה	כותנה	כותנה	כותנה
מקור מים *1	ניטראט	ניטראט	ניטראט	ניטראט	ניטראט	ניטראט
מקור מים *2 *	מי נגר	מי נגר	מי נגר	מי נגר	מי נגר	מי נגר
מקור מים 1	ניטראט	ניטראט	ניטראט	ניטראט	ניטראט	ניטראט
מקור מים 2	מי נגר	מי נגר	מי נגר	מי נגר	מי נגר	מי נגר
מקור מים 1	ניטראט	ניטראט	ניטראט	ניטראט	ניטראט	ניטראט
מקור מים 2	מי נגר	מי נגר	מי נגר	מי נגר	מי נגר	מי נגר
מקור מים ***3	פר כלורט	פר כלורט	פר כלורט	פר כלורט	פר כלורט	פר כלורט
מקור מים #4	ניטראט +	ניטראט +	ניטראט +	ניטראט +	ניטראט +	ניטראט +

* מקור מים 1- ניטראט כ-130 מג״ל, משטר זרימה רציף עד ארבעה ימים עם הפוגה של שבוע
** מקור מים 2 - מי נגר עירוני, משטר זרימה מנתי של אירוע לשבוע למשך 6 שבועות
*** מקור מים 3 - פרכלורט, משטר זרימה רציף
# - מקור מים 4 - ניטראט + כלורידים, רציף, על-מנת לדמות המלחת מי תהום

בהקשר זה הפרמטרים התפעוליים:

עומס השקייה להדמיית טיפול במי-שיטפונות: 15 ליטר (אירוע שבועי אחד) לקולונה.

אקלימציה של המערכות: ארבע השקיות במשך חודש בהרכב הזנה מעורב הכולל הדמייה של מי-שיטפונות עם ריכוז גבוה של ניטרט.

מחזורי הפעלה לאחר אקלימציה: שלושה מחזורים, שכל אחד כולל שבוע עד שבועיים מי-תהום מזוהמי ניטרט (הזנה רציפה 50 ליטר/יום לקולונה) ואחריו שישה שבועות טיפול במי-שיטפונות (אירוע שבועי יחיד של 15 ליטר).

חתך הקולונות (מלמטה למעלה): 10 ס"מ סוססום בזלת 3-5 מ"מ, 10 ס"מ חול 0.8-2.5 מ"מ, 35 ס"מ חול 0.4-0.6 ס"מ (שכבה עובדת עם תוסף פחמן), 10 ס"מ חול 0.4-0.6 מ"מ, 35 ס"מ חמרה. גובה אזור רווי 55 ס"מ. שלוש קולונות קצרות אותו סידור בגבהים: 5, 5, 10, 10, 20 ס"מ.

הערה: יתכן שינוי תכנית זו עקב המשקל הכולל של הקולונות וחביות מי ההזנה על גג הבניין המותנה באישור קונסטרוקטור לעומס מותר בגג.