Ground Penetrating Carbon, Inc.

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GPC FILTER PROCESS

The GPC Filter Process (patent pending) is a process by which a highly available organic carbon is mixed with effluent from an existing tertiary treatment wastewater system, and then dosed onto a filter known as a GPC Filter. The GPC Filter is a sand filter that has been constructed to mimic the stratified soil formation of coastal outwash plains and sandy alluvial soils. The operation of the GPC filter has been designed to take advantage of the naturally occurring soil microorganisms within the soil. The filter utilizes these soil microorganisms to further treat the effluent from the wastewater system. The GPC filter can be added on-line at a wastewater treatment system or used as a soil absorption system (SAS) as a bottomless configuration.

The GPC Filter Process was developed at a wastewater treatment facility in Mill Pond Village in Yarmouth, Massachusetts. The stratified sand filters were originally installed to reduce the Total Suspended Solids (TSS) in the treated effluent prior to disinfection by ultraviolet (UV) light.

During the project, we modified the treatment train by adding the organic carbon to the treated wastewater prior to dosing the stratified sand filters. By doing so, we altered the make-up of the dissolved pollutants in the effluent to fit the needs of the soil bacteria in the sands. Over time, we developed the ideal ratio of carbon to nitrogen in the treated effluent dosed to the GPC Filter to achieve high removal rates of Five Day Biochemical Oxygen Demand (BOD_5), Total Suspended Solids (TSS) and Total Nitrogen (TN) removal. The effluent from the GPC Filter was then subjected to UV light as a final disinfection treatment before being dosed to the SAS. The effluent leaving the UV chamber at this facility is tested weekly by composite samples. The performance of the GPC Filter Process has been excellent.

Composite samples of the final effluent are collected by a wastewater treatment plant operator from a sampling point prior to discharge into the soil absorption system. The composite sampler withdraws 1/48th of the required volume every half hour over a 24 hour period. The samples are then retrieved, kept on ice, and transported to a certified testing laboratory for analysis. The results from the tests for the time period of 05/13/11 to 10/31/14 are as follows:

Mill Pond Village
From 05/13/11 To 10/31/14
Final Effluent (composite samples)

	BOD_5 (mg/L)		TSS (mg/L)		TN (mg/L)		NO_3 (mg/L)
Average	3.1		2.3		5.1		4.5
Total Tests	181		181		181		181
Non-Conformities	0		3		13		7
Total Over Detection	6		23		n/a		n/a
Detection Level	3		3				
Total Below Detection level	175		158				
Percent Compliant	100%		98%		92%		96%
Median	3.0		1.5		4.2		3.5
High	13.7		14.0		23.1		22.2
Low	3.0		1.5		0.8		0.4

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There are only a few wastewater treatment systems that can consistently discharge final effluent with the concentrations of Five Day Biochemical Oxygen Demand (BOD_5) and TSS below detection level. The chart shows 13 non-conforming tests for TN and 7 non-conforming tests for Nitrate (NO_3). The non-conforming TN and NO_3 concentrations occurred when the upstream system discharged elevated concentrations of dissolved nitrogen. These non-conformities are not significant since non-conformities in wastewater treatment are common and the system did return to compliance. In 2013, about 20% of the wastewater treatment facilities in Massachusetts discharged final effluent with tested levels of these nitrogen constituents exceeding the permit limit.

The raw influent entering the wastewater treatment system is sampled on a monthly basis. The difference between the TN concentrations of the raw wastewater compared to the TN concentrations of the final effluent indicates that the entire wastewater treatment system has removed about 95% of total nitrogen on average. The GPC Filter removed about half of the TN concentration in the effluent stream.

Because of the excellent removal rates of BOD_5 and TSS at the Mill Pond system in October and November of 2014, grab samples were taken from sample ports placed before and after the GPC Filter. These samples were taken and shipped to Eurofins Eaton Analytical Laboratories (Eurofins) for analysis of Pharmaceuticals and Personal Care Products (PPCPs). The ultraviolet light was disabled when the samples were drawn, so only the GPC process performance was measured.

In the October 2014 tests, Eurofins performed a suite of testing for 95 PPCPs. Eurofins did find certain PPCPs in the GPC Filter influent and effluent. Below, we have listed the detected PPCPs by type of chemical as reported by Eurofins:

GPC Filter Process Removals

Pharmaceuticals	**Removal Rate**
Amoxicillin (semi-quantitative)	99%
Atenolol	89% to 93%
Azithromycin	increase
Butalbital	increase
Carbamazepine	2% to 43%
Dilantiazem	54% to 99%
Ibuprofen	89% to 99%
Lidocaine	29% to 32%
Lopressor	80% to 88%
Naproxen	91% to 99%
Pentoxyphylline	87% to 99%
TCEP	29% to 35%

Household Chemicals	**Type**	**Removal rate**
Acesulfame-K	Artificial Sweetener	97%
Caffeine	Simulant from coffee	74% to 92%
Cyanazine	Pesticide	1% to 92%
DEET	Insect Repellent	70% to 99%
Isobutylparaben	preservative	11% to 99%
Sucralose	Artificial Sweetener	Increased
TCPP	Flame Retardant	66% to 99%
TDCPP	Flame Retardant	54% to 99%
Triclocarban	Antibacterial	72% to 99%

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In the group of chemicals labelled “Household Chemicals”, we added the column labelled “Type” and the estimated removal rate. Since Eurofins reports the concentrations at the level of 1 part per trillion, the removal rates are calculated using the minimum detection level added and subtracted from the reported values. Since there can easily be variations in water quality, these tests have to be repeated for precise validation.

The removal rate of the flame retardants is impressive given that these chemicals are normally considered resistant to microbial attack.

The removal capability of PPCPs in the treated effluent passing through the GPC Filters was unexpected to us. It appears that the soil bacteria in the filter, attack the organic compounds, even at trace levels, and use the carbons for metabolism. This is superior to other accepted methods of removing these pollutants. Most other technologies remove these dissolved chemicals through membranes, using reverse osmosis or by chemical separation. All of these other methods generate a brine from the influent end of the membranes. The brine then has to be treated or stored in a hazardous waste landfill and becomes an additional concern for our environment. Unlike these other pollutant removing technologies, the discovery that these stratified sand filters may remove, by metabolism, organic pollutants from the water, is an exciting find.

We tested the GPC process at a second treatment system with a GPC Filter serving two assisted living facilities in Falmouth. The effluent is tested monthly. The results of the tests confirm the excellent removal of BOD_5 and TSS by the GPC process. A chart of the test results is below:

ATRIA Woodbriar Falmouth MA **From 09/23/13 to 11/20/14**
Final Effluent (composite sample)

	Daily Flow	BOD_5 (mg/L)	TSS (mg/L)	TN (mg/L)	NO_3 (mg/L)
Discharge Limit	39,750 gpd	30	30	10	10
Average	11,938 gpd	3.0	2.4	6.1	4.8
Mean	11,704 gpd	3.0	1.5	5.8	4.6
Detection Level		3.0	1.5		0.05
Count		15	15	15	15
Non-Conformities	n/a	0	0	1	1
Conforming	n/a	100%	100%	93%	93%

This system also had final effluent with concentrations of BOD_5 and TSS approaching detection level. The non-conformity of Total Nitrogen at Atria was in the first month of operation.

A GPC filter can be easily added to wastewater treatment facilities over 10,000gpd. For systems under 100,000gpd, the construction requires a permit under the piloting program of Title-5.

A copy of a memorandum describing the test results can be requested from us.