



inc. BIOLOGICAL CONSULTING SERVICES  
OF NORTH FLORIDA, INC.

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December 02, 2015

Mr. Travis Merrigan  
Grayl Inc.  
610 Maple Heights Rd  
Camano Island, WA 98282

Re: Bacterial and viral filtration efficacy testing of the Grayl Travel Purifier+ Filters using waters of varying turbidity: BCS ID 1511178, 1511179 and 1511180.

To whom it may concern,

We have conducted the requested biological filtration efficacy study on the provided filters. The Travel Purifier filters were received on November 16<sup>th</sup>, 2015. The experimental set up and challenge of the filters was based on client's request. It was conducted to evaluate the filters' bacterial and viral filtration efficacy during the use of water with increasing turbidity. The contaminant species and water parameters selected were based on client's request and NSF/ANSI water purifier test protocols.

Following, you will find our report on the results of the challenge study. Should you have any questions, please do not hesitate to contact me.

Sincerely,

George Lukasik, Ph.D.  
Laboratory Director

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BCS LABORATORIES, INC. - GAINESVILLE  
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FL DOH #E82924, ISO/IEC 17025:2005 L2422 (L-A-B), EPA# FLO1147

FILE: GRAYL TRAVEL PURIFIER+ 1NTU, 10NTU & 30NTU BCS 1511178-180 12.02.2015

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**Test Article(s):**

On November 16<sup>th</sup>, 2015 three personal water filtration units: Travel Purifier were received at BCS labs. The units were submitted by Grayl, Inc for microbial filtration efficacy testing. The units were assigned BCS ID's 1511178, 1511179, and 1511180.

**Table 1. Critical equipment and supplies used in study for measurement and analysis**

| Equipment and Measurement Parameter            | Manufacturer                              | BCS Lab ID |
|--|---|------------|
| Balance  | Sartorius Laboratory Instruments          | BL-5       |
| Turbidity meter                                | Hach Turbidity Meter                      | TM-01      |
| Total hardness test kit                        | LaMotte                                   | 4911208    |
| Incubator                                      | Sanyo MIR-253                             | I-2        |
| pH   | Denver Instrument Traceable UB-5          | PH-1       |
| Conductivity/TDS                               | Omega Traceable Conductivity Meter CDH-27 | CM-1       |
| Timer  | VWR Traceable 61161-346                   | T-10       |
| Centrifuge                                     | Eppendorf C-5702                          | C-12       |
| Temperature                                    | VWR traceable IR Thermometer              | IR-4       |
| 4 Liter standardized graduated cylinder        | Nalgene                                   | GC-4L-A    |
| 500 milliliter standardized graduated cylinder | Nalgene                                   | GC-500ML-C |

**Project:** Grayl Travel Purifier+ Filters' Efficacy Test with Increasing Turbidities  
**Study Sponsor:** Grayl Inc.  
**Sample(s):** BCS 1511178, 1511179, & 1511180 received November 16<sup>th</sup>, 2015  
**Test:** Filtration Efficacy  
**Test Parameter:** *Raoultella terrigena* (Bacteria)

| Filter ID  | Turbidity                       | Filter Influent average concentration | Average percent removal** of <i>Raoultella terrigena</i> <sup>1</sup> (Bacteria) by filters after the indicated flow of challenge water |            |            |                  |                  |                  |                  |
|------------|---------------------------------|---------------------------------------|---|------------|------------|------------------|------------------|------------------|------------------|
|            |                                 |                                       | 1 Gallon  | 10 Gallons | 20 Gallons | 30 Gallons       | 40 Gallons       | 50 Gallons       | 60 Gallons       |
| BCS1511179 | 1 NTU<br>(Clear Water)          | 1.6 x 10 <sup>5</sup> cfu/mL          | >99.9999%*  | >99.9999%* | >99.9999%* | >99.9999%*       | >99.9999%*       | >99.9999%*       | >99.9999%*       |
| BCS1511178 | 10 NTU (Turbid Water)           | 1.7 x 10 <sup>5</sup> cfu/mL          | >99.9999%*  | >99.9999%* | >99.9999%* | N/A <sup>†</sup> | N/A <sup>†</sup> | N/A <sup>†</sup> | N/A <sup>†</sup> |
| BCS1511180 | 30 NTU<br>(Highly Turbid Water) | 2.7 x 10 <sup>5</sup> cfu/mL          | >99.9999%*  | >99.9999%* | >99.9999%* | N/A <sup>†</sup> | N/A <sup>†</sup> | N/A <sup>†</sup> | N/A <sup>†</sup> |

<sup>1</sup> *Raoultella terrigena* (ATCC 33257) was obtained from ATCC and propagated on Tryptic Soy Agar (TSA, Becton Dickinson, USA). It is used to evaluate filters' bacterial removal efficacy. Bacteria was enumerated as colony forming units (cfu) following incubation at 36.5°C for 24 hours as per Standard Method 9215C (APHA, 2012).

\* No species were detected in the filter effluent for the total volume analyzed (<0.45 cfu or pfu/ml). Filter effluent samples were analyzed in duplicates at the minimum following collection.

<sup>†</sup> The study was discontinued due to clogging of filter and filtrate flow reduction by >85%.

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**Test:** Filtration Efficacy  
**Test Parameter:** Bacteriophage MS-2 (Virus)

| Filter ID  | Turbidity                       | Filter Influent average concentration | Average percent removal** of MS Bacteriophage (Virus) <sup>1</sup> by filters after the indicated flow of challenge water |            |            |                  |                  |                  |                  |
|------------|---------------------------------|---------------------------------------|---|------------|------------|------------------|------------------|------------------|------------------|
|            |                                 |                                       | 1 Gallon  | 10 Gallons | 20 Gallons | 30 Gallons       | 40 Gallons       | 50 Gallons       | 60 Gallons       |
| BCS1511179 | 1 NTU<br>(Clear Water)          | 3.0 x 10 <sup>5</sup> pfu/mL          | >99.9998%*  | >99.9998%* | >99.9998%* | >99.9998%*       | >99.9998%*       | >99.9998%*       | >99.9998%*       |
| BCS1511178 | 10 NTU (Turbid Water)           | 5.4 x 10 <sup>5</sup> pfu/mL          | >99.9999%*  | 99.9996%   | 99.9999%   | N/A <sup>T</sup> | N/A <sup>T</sup> | N/A <sup>T</sup> | N/A <sup>T</sup> |
| BCS1511180 | 30 NTU<br>(Highly Turbid Water) | 3.3 x 10 <sup>5</sup> pfu/mL          | >99.9999%*  | >99.9998%* | >99.9998%  | N/A <sup>T</sup> | N/A <sup>T</sup> | N/A <sup>T</sup> | N/A <sup>T</sup> |

<sup>1</sup>Bacteriophage MS-2 (ATCC 15597-B1) was used as a model for human viruses. It is of similar shape and size to human enteroviruses and thus is used to determine filter's viral capture efficacy. It was enumerated using *E. coli* C3000 (ATCC 15597) as a host using the single layer plaque assay agar procedure as per EPA 1601.

\* No species were detected in the filter effluent for the total volume analyzed (<0.45 cfu or pfu/ml). Filter effluent samples were analyzed in duplicates at the minimum following collection

<sup>T</sup> The study was discontinued due to clogging of filter and filtrate flow reduction by >85%.

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**Test:** Filtration Efficacy  
**Test Parameter:** *Raoultella terrigena* (Bacteria) and Bacteriophage MS-2 (Virus)

\*\* Brief Challenge study description: For each challenge water type study, one of the filters was fitted into a modified Grayl bottle base. The base was connected directly to a digital gear pump (Cole Palmer, USA) that provided a continuous flow of challenge water through the test filter. Forty gallons of municipal water supply was dechlorinated by passage through EP-BB carbon block filter cartridge (Pentek, USA) and adjusted to a pH of 7.35 +/- 0.15. Aliquots of *Raoultella terrigena* and bacteriophage MS-2 were added to the water and homogenized. The turbidity was adjusted for each respective test study by the use of ISO 12103-1, A2 Fine Test Dust (PTI, USA) and maintained at +/- 0.1 NTU throughout each test study. The particular challenge water was passed through a filter at a starting flow rate of 420mL/min. The unit's filtrate reservoir was steadily filled as the challenge water flowed through the filter. Samples from the filter influent and effluent were removed following the passage of the indicated volume of challenge water. The samples were assayed for the respective species as per standard methods and Lab Standard Operating Procedures (SOP F-1). The filtrate flow was monitored throughout the study. In both the 10 NTU and the 30 NTU studies, the filtrate flow was significantly reduced following the passage of 15 gallons. Following the passage of 20 gallons of turbid and highly turbid challenge water, the flow was reduced by >85% and the study was discontinued after the collection of the effluent sample and declaring the filters inoperable due to clogging. All analysis was conducted on each sample in duplicate at minimum for a minimum of two assay volumes. The number of microorganisms was determined in each sample. The respective percent reductions were determined based on the concentration obtained in the filter influent and analyzed effluent sample. NSF/ANSI Purifier standard microbial removal claims are 99.9999% or greater for bacteria, 99.99% or greater for virus, and 99.9% or greater for parasite cysts.

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**Test Parameter:** *Raoultella terrigena* (Bacteria) and Bacteriophage MS-2 (Virus)

**Study Date:** Study was initiated on November 20<sup>th</sup> and completed on December 01, 2015.

**Performed by:** David Sekora, M.S.  
**Analyzed by:** David Sekora, M.S.  
**Study Supervisor:** George Lukasik, Ph.D.

**Study Notes:** The data obtained from the described study indicate that solely increasing the turbidity of the water did not decrease the filtration efficacy of the filter cartridge tested. Water with high dust loading did cause the flow to decrease and thus the filters to clog. However, microbiological contaminants were continuously removed from the challenge water by the filter tested. Turbidity was the sole factor that was increased and studied to determine its effect of filtration efficacy.

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Study data are summarized in the provided table(s). The results presented pertain only to the study conducted on the test articles/samples provided by the client (or client representative). The study was authorized and commissioned by the client. The results presented pertain only to the samples analyzed and identifier number(s) indicated. The data provided is strictly representative of the study conducted using the material/samples/articles provided by the client (or client's representative) and its (their) condition at the time of test. The study and data are obtained under laboratory conditions and may not be representative or indicative of a real-life process and/or application. Positive, negative, and neutralization controls were performed as outlined in the method and as per Good Laboratory Practices. All analyses were performed in accordance with laboratory practices and procedures set-forth by our NELAP/TNI accreditation standards (ISO 17025) unless otherwise noted. BCS makes no claims with regards to the express or implied warranty regarding the ownership, merchantability, safety or fitness for a particular purpose of any such property or product.



Signature of Laboratory Director/Authorized Rep. \_\_\_\_\_ Date: December 2, 2015

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