

INTRODUCTION

Ingesting microbiologically contaminated water is one of the most common sickness routes for people living off the grid, such as remote communities and those travelling with recreational vehicles. Ultraviolet (UV) disinfection utilizes strong short-wavelength (250–280 nm) radiation to inactivate microorganisms by destroying the nucleic acids and disrupting their DNA, leaving them unable to perform vital cellular functions.

Currently, many major cities in Canada, United States, and Europe, such as Vancouver, New York, and Paris have adopted UV as their primary water disinfection process, making UV one of the fastest growing water treatment technologies. Yet, conventional UV lamps face several challenges including high power requirements, which is not normally available in remote communities and off-grid regions.

Here we show the successful use of UV-LED water purification systems for off-grid disinfection of surface water, which has not been available through conventional disinfection methods. The results of case studies on the off-grid disinfection of Grand River and Laurel Creek surface water using Acuva Technologies UV-LED water purification system are presented. Microbial test was conducted through evaluating the concentration of total coliform (TC) and *E. coli* microorganisms. The results indicated the effective inactivation of TC and *E. coli*, even at water with low UV transmittance (UVT). These data are in agreement with the intent of National Sanitation Foundation (NSF) 55 standard, recommending minimum of 40 mJ/cm² for disinfection of surface water.

Materials & METHODS

Multiple samples of surface water and synthetic water were evaluated in this case study:

1) Surface water – Grand River and Laurel Creek, Waterloo, ON: Off-the-grid water disinfection was conducted using flowing and stagnant water, utilizing Acuva's UV-LED water treatment system (Arrow) after a 10 μm carbon filter without pre-treatment.



Figure 1: Off-grid UV-LED system performance evaluation in Waterloo, Canada.

2) Surface water – Fraser River, Vancouver, BC: Water sample was taken from flowing water at Fraser River south of Vancouver, and disinfection test were conducted using Acuva Eco 1.0 UV-LED system in laboratory.



Figure 2: Off-grid UV-LED system performance evaluation in Vancouver, Canada [1].

3) Synthetic water – E. coli ATCC 8739: The controlled microbiological test was performed using standard stock solution of *E. coli* ATCC 8739 (2×10^9 CFU/100mL) diluted to 10^6 CFU/100mL for microbiological test.



Figure 3: Controlled UV-LED system performance evaluation in Vancouver, Canada.

Bioassay sample evaluation was conducted through membrane Filter Technique for Members of The Coliform Group (9222) – Standard Methods for the Examination of Water and Wastewater – 22nd Edition - American Public Health Association, American Water Works Association, Water Environment Federation [2], conducted at accredited microbiological laboratory on United States Environmental Protection Agency (USEPA) Ultraviolet Disinfection Guidance Manual (UVDGM) and Canadian Association for Laboratory Accreditation (CALA) protocols.

RESULT

Table 1 summarizes the results of microbial analysis.

Table 1: Microbial analysis data of the off-grid UV-LED water disinfection test. Samples were collected at various UV dose (flow rate control) at the Grand river and Laurel Creek.

#	Source	Description	TC Counts (CFU/100 mL)	95% confidence
1	Grand River and Laurel Creek	Before treatment	1700	±492
			1700	
			900	
			1000	
2	Grand River and Laurel Creek	UV-LED 50 mJ/cm ²	<1	N/A
			<1	
			<1	
			<1	
3	Grand River and Laurel Creek	UV-LED 40 mJ/cm ²	<1	N/A
			<1	
			<1	
			<1	
4	Grand River and Laurel Creek	UV-LED 30 mJ/cm ²	6	±5
			10	
			6	
			2	
5	Fraser River	Before treatment	20	±24
			42	
			5	
			25	
6	Fraser River	UV-LED 20 mJ/cm ²	<1	N/A
			<1	
			<1	
			<1	
7	Control	Before treatment	1,600,000	±129922
			1,700,000	
			1,800,000	
			1,700,000	
8	Control	UV-LED 20 mJ/cm ²	<1	N/A
			<1	
			<1	
			<1	

CONCLUSIONS

Here we show an example of UV-LED water disinfection in the regions that most of the incumbent technologies, including UV-lamp based devices cannot be operated.

An off-grid microbial analysis was conducted to evaluate the performance of Arrow 5 UV-LED water purifier for UV-LED disinfection of surface water. Microbial tests were carried out with water samples from Grand river and Laurel Creek in Waterloo, Canada, and the samples were analyzed by EPA approved laboratory in Canada.

Samples were analyzed based on Ultraviolet Disinfection Guidance Manual (UVDGM) and Canadian Association for Laboratory Accreditation (CALA) protocols.

In agreement with NSF 55 Class A guidelines, the results of microbial analysis suggested that safe drinking water can be obtained once surface water is treated with 40 mJ cm⁻² UV dose and above. In cases of supplemental disinfection systems, Aligned with NSF 55 Class B, lower UV Doses, above 16 mJ cm⁻² is sufficient for drinking water purposes.

Many communities, including 127 First Nation communities in Canada, do not access to source of high power; therefore, UV-LED water treatment systems can be used for complete elimination of microbial contaminants and potentially lifting the boil water advisory in these regions.

References:

[1] <https://www.mapleridgenews.com/>, Accessed May 2019.

[2] E.W. Rice, R.B. Baird, A.D. Eaton, L.S. Clesceri, American Public Health Association, American Water Works Association, Water Environment Federation, 2012. ISBN: 9780875530130