Field Measurement and Verification of the Lenard Effect and its Impact on the Creation of Naturally Occurring Air Ionization.

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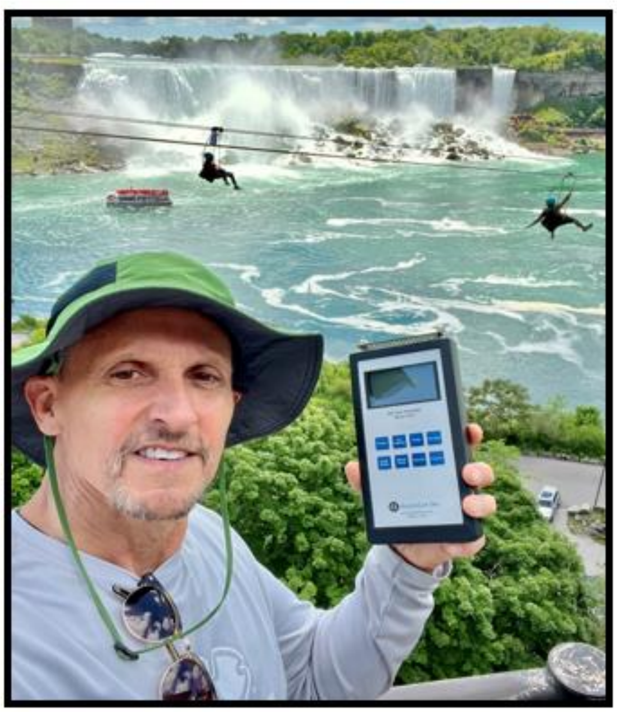
Preface

During the recent American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Summer Conference held in Toronto, Canada (June 25-29,2022) I took a break from the weeks technical activities and made the short drive to Niagara Falls. With ion meter in hand, my day included a boat ride, waterfalls, field measurements, and some unanticipated results. This paper details that excursion and what I discovered along the way.



What is the Lenard Effect?

Philipp Eduard Anton von Lenard was a Hungarian-born German physicist and the winner of the Nobel Prize for Physics in 1905. Based on considerable experimentation, he proved that negatively charged electricity (air ions) are generated when water droplets collide with each other, or with a wetted solid (in places where water splashes) such as with waterfalls or fountains, rivers, lakes, oceans, rain, mist and fog. His discovery was later named the Lenard effect and is one of several ways that nature can impart massive quantities of ionization to the air we breathe. But regardless of how they are created, this occurs in outdoor locations where we typically consider air to be the most pristine.

About 71% of the earth's surface is covered by water. With more than 326 million trillion gallons of water covering our planet it's easy to comprehend the contribution this massive natural resource may make in ionizing the outdoor air. Natures impact on the ionization of air is soundly based on science and our current understanding of the Lenard Effect.

The Lenard Effect and Our Outdoor Atmosphere

Ions occur naturally outdoors and are prevalent in the air we breathe. Atmospheric air ions are generated from a variety of natural sources, such as changes in atmospheric and weather conditions including lightning, sunlight, rain, wind, waterfalls, and snow as well as from plants, natural radioactivity in geological formations, cosmic radiation, and combustion processes. According to Walter Lewin, Professor of Physics Emeritus at Massachusetts Institute of Technology, each day there are thousands of thunderstorms accompanied by hundreds of lightning flashes every second all across the earth. Falling water (raindrops) can become charged through friction (Lenard effect) and along with the other naturally occurring phenomena discussed, contribute to the natural ionization of outdoor air.

Scientists and meteorologists have measured variations of the electrical charge in the air for more than 100 years. Naturally occurring levels of outdoor ions are greatest where the air is the cleanest, for example at a beach near the ocean, or on a mountaintop. Ion counts at these locations may measure anywhere from 3,000 to 21,000 ions per cubic centimeter (ions/cc) in both polarities (1). When ions are measured in more polluted urban environments, naturally occurring ion levels become depleted and may measure considerably less (2). Inside buildings, where the U.S. Environmental Protection Agency (EPA) warns us that the air we breathe may be the most highly polluted, these levels can be diminished even further as ions are depleted during their interaction with contaminates in the air (3). Various pollutants have the effect of reducing the amount of naturally available ionization in ambient air. The concept of artificially ionizing the indoor air, with both positive (+) and negative (-) ionization (termed bipolar ionization) has been recognized to help replenish the concentration of indoor air ions to a level more consistent with that of the outdoors, where the air has traditionally been the cleanest (4).

(1) I have made hundreds of ion measurements and have often measured outdoor air ion concentrations in these ranges. I have witnessed highs of (-) 28,140 ions/cc at a mountain top in Colorado (elevation 12,240 ASL) and over (-) 55,000 ions/cc at a waterfall near my home in Asheville, NC. during fair weather conditions (no storms).
(2) As we move inland, towards more highly polluted urban environments, air ion concentrations drop considerably to where (for example) in metro downtown environments I have measured ion concentration more in a range from (-)500 to (-)1500 ions/cc.
(3) I have measured indoor ion concentration as low as (-) 50 ions/cc in indoor healthcare settings, and typically experience numbers ranging from 300-500 ions/cc in office spaces, such as occupied conference rooms. More highly polluted indoor environments will have lower actively charged ion concentrations in the air, as their energy potential is rapidly depleted through interaction with certain airborne contaminants as they attempt to help remediate them.
(4) Having performed air ionization measurements for over 14-years, I now typically measure only negative ion concentrations in effort to conserve time. I have found that positive ion concentrations consistently lag those of their negative counterpart by approximately 40-60%. Through my search of scientific literature explaining this occurrence, the rationale appears to be that during fair weather the earth's surface is negatively charged, and therefore will attract positive ions from the surrounding air (diminishing their concentration) in effort to reach an electrically balanced (neutral) state. Remember, opposite polarities will attract one-to-another when dealing with magnets as well as charged air ions and particles.

*Note: You can learn more about the Lenard Effect, ionization in general, and bipolar ionization in my peer reviewed American Society of Heating, Refrigerating and Air-Conditioning (ASHRAE) Journal article titled "*A Bipolar Ionization Primer for HVAC Professionals*" in the November 2021 edition.

Why Measure the Lenard Effect at Niagara Falls?

Niagara Falls is a group of three waterfalls at the southern end of Niagara Gorge, spanning the border between the province of Ontario in Canada and the state of New York in the United States. 3,160 tons of water flows over Niagara Falls every second. This accounts for 75,750 gallons of water per second over the American and Bridal Veil Falls and 681,750 gallons per second over the Horseshoe Falls. That's enough to fill up an Olympic size swimming pool in half a second, or about a million bathtubs every minute.

Niagara Falls is an immense, natural body of constantly flowing water that is also extremely turbulent, the perfect location from which to measure potentially enormous quantities of air ionization emitted directly by this source…in other words, it's the jack pot of ion generation.

What Science has Learned About the Lenard Effect?

"Electricity in a waterfall" is a paper written by Lenard where he summarized the phenomenon of the Lenard effect based on his experiments. He won the Nobel Prize for Physics in 1905, not for the Lenard effect but for his research on cathode rays, the early beginnings of what today has evolved into bipolar ionization.

It is my belief that what Lenard discovered over a century ago is what modern-day scientists refer to as "soft ionization." As Hartley and Kanik , in their paper titled "*A nanoscale soft-ionization membrane: A novel ionizer for ion mobility spectrometers for space applications*" describe it, "soft ionization mechanism does not fracture the target molecules or cause any secondary ionization." This is because the kinetic energy of the emitted electrons is low, which results in electrically charged water molecules void of potential byproducts (such as ozone). Byproducts may easily be produced through higher energy exchange mechanisms.

Validating the Lenard Effect

While ions in the air cannot be seen, felt, or sensed by human beings, we most certainly can measure them with the appropriate metering equipment. For my field measurement and verification, I used a commercially available Alpha Labs AIC2 Air Ion Counter. This is a handheld meter designed to measure ion density, or the number of ions per cubic centimeter (ions/cc) in air. It measures this number separately for positive and negative ions (+ and – ions are usually present simultaneously). This instrument is a true ion density meter, based on a Gerdien Tube Condenser design, and it contains a fan which draws air through the meter at a calibrated rate. The unit comes as a dual-range model, and the device I used has selectable maximum ranges of both 2 million and 200 million ions/cc. I used the 2 million scale for my outdoor measurements at Niagara Falls, while the 200 million ions/cc range is more suitable for measuring close to electric ionization devices or strong radioactive sources.

Air Ion Counter Model AIC2 Operation

Air is drawn in at the top of the meter, measured, and exits at the bottom. The display shows the ion count within 1 second and it continues to display the ion density in the air, showing any changes within 1 second after they occur. The POLARITY selection determines whether + or – ion density is measured. The meter operates on four AA batteries or an external 6V to 9VDC supply. I used new, fully charged batteries for my testing. Note that solids do not produce ions unless there is an energy source (such as radioactivity, high voltage or heat above about 600° C). Liquids evaporating or droplets splitting apart can produce air ions.

Field Measurement and Verification

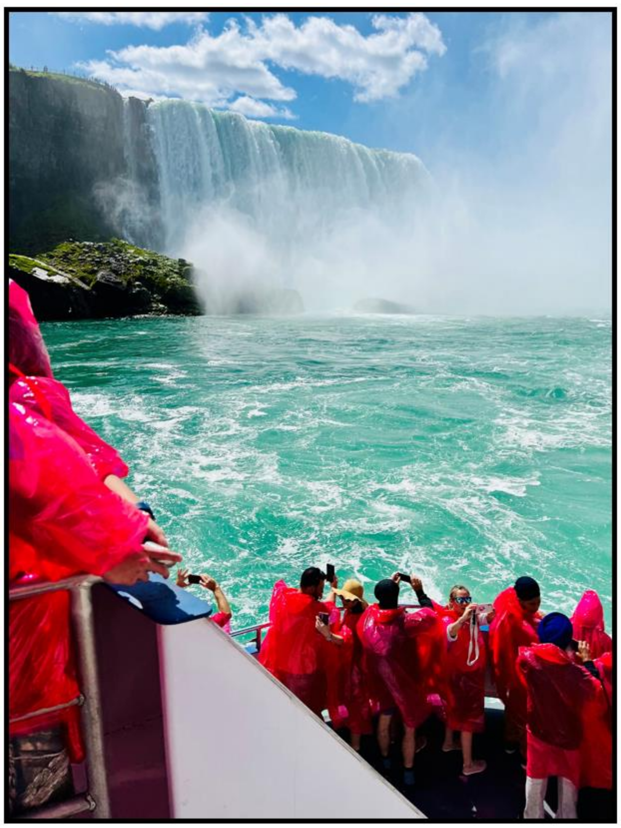
Using the Alpha Labs AIC-2 handheld ion counter (picture above) I set out to make air ion measurements at various locations throughout Niagara Falls. I felt confident, based on past experience, that I would be measuring elevated levels, but I was not prepared for what I was about to witness and record. Niagara Falls may possibly be the largest sole source, continually emitting ionization generator on the planet (prove me wrong). I had some preconceived notions of the measurements I might see, all of which were completely blown away after a day on the falls studying this scientific phenomenon in great depth.

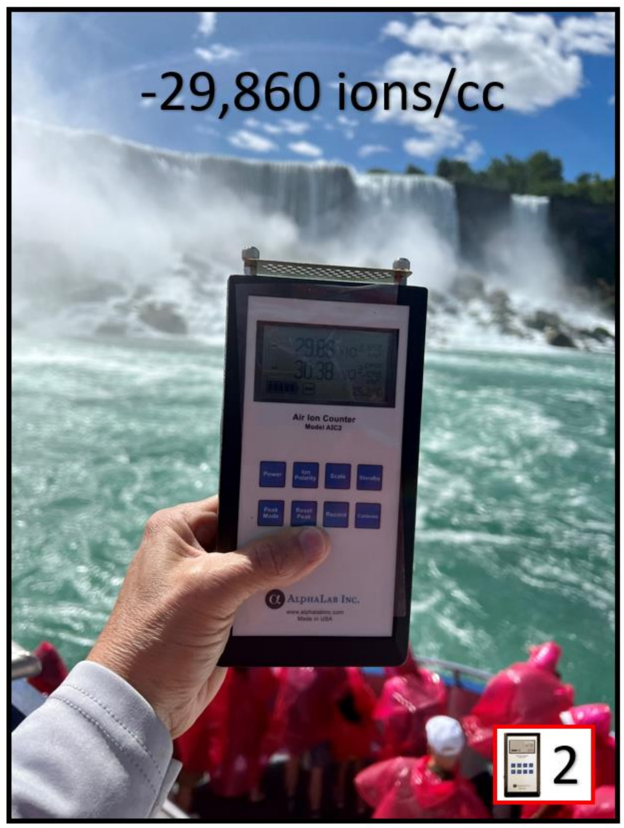
What I have learned during 14-years of making field ion measurements is that this exercise is as much an art as it is a science. Ions move with air, and greater air volumes can convey more ions. Higher air velocities (wind speed) also helps to move ions much quicker. Depending on source, concentration, air quantity, quality, and velocity, air ion measurements can vary drastically in the same location over just a few seconds of time. What I attempt to do is allow any breeze to stabilize, then watch for the meter counts to plateau for several seconds before I record what represents the average air ion concentration in that particular sampling. With practice you can learn to make these assessments quickly, accurately, and with repeatability.

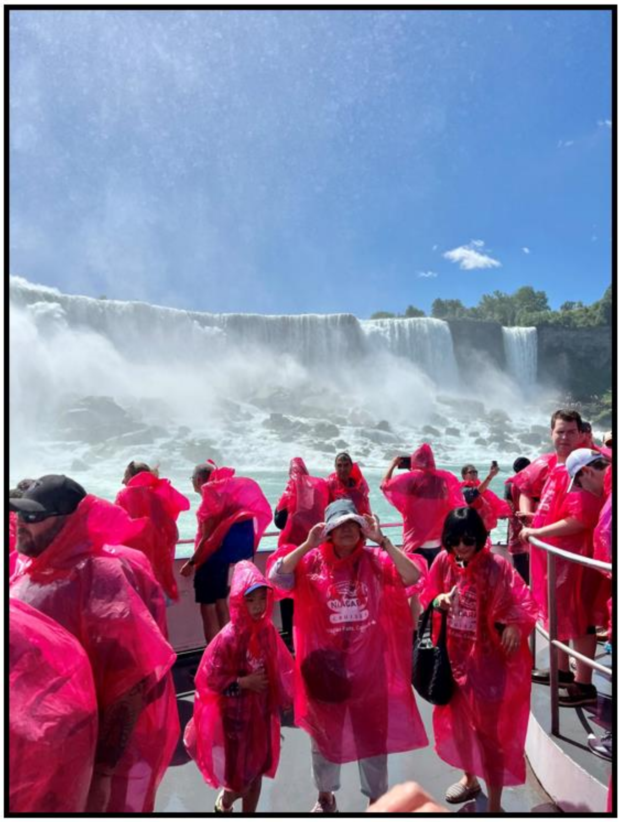
I have included a map of my various sampling locations, along with accompanying photos of the AIC-2 meter and the actual ion count registered (in ions/cc) using the methodology I briefly described above. For reference, the outdoor temperature was approximately 77°F at street level and the time approximately 11-AM Eastern. Temperature within the falls was approximately 62°F at its coolest due to an evaporative cooling effect on the air from the cascading water.

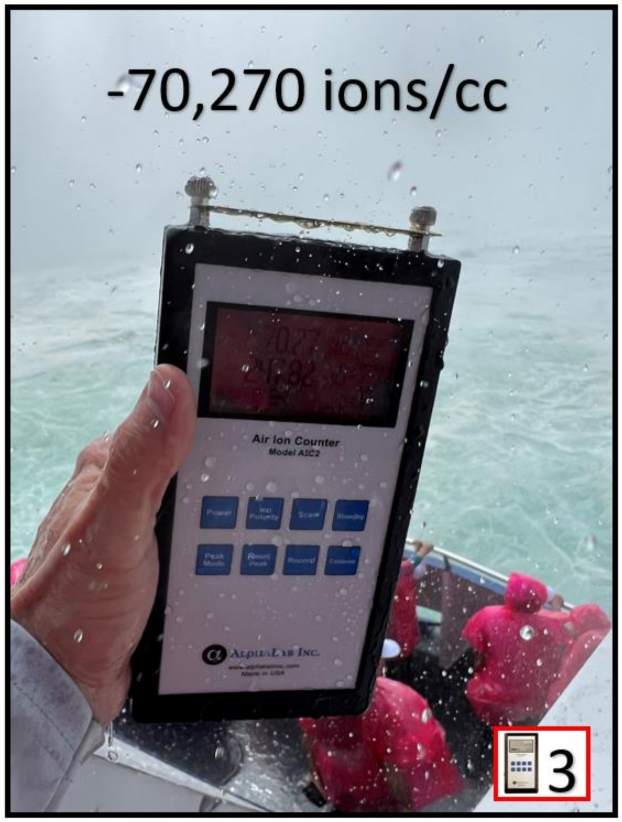
TAG	LOCATION	- ION COUNT
1	Boat Landing	-16,900
2	Leaving Landing	-29,860
3	Close to American	-70,270
4	Far from Horseshoe	-32,180
5	Closer to Horseshoe	-1,422,510
6	Inside Horseshoe	-1,692,100
7	Overlook American	-44,840
8	Overlook Horseshoe	-100,380

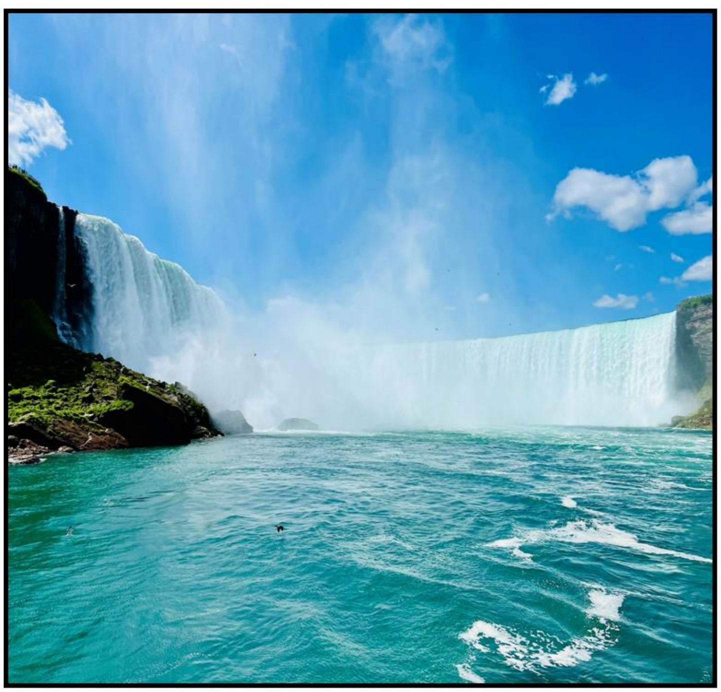

-16,900 ions/cc
Air Ion Counter
Model AIC2
1

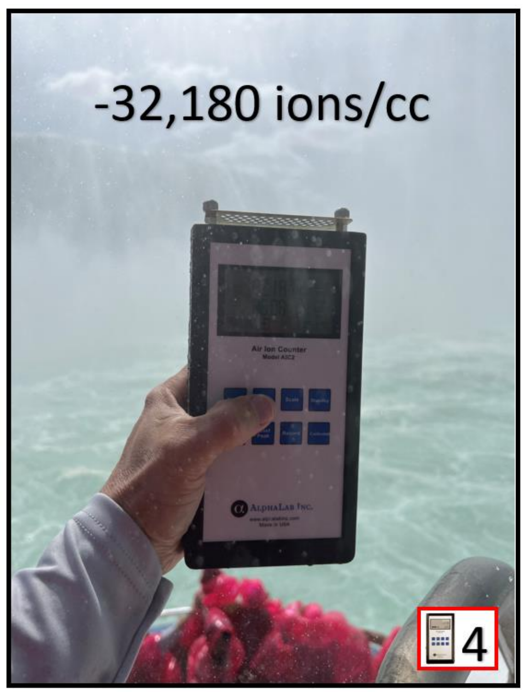


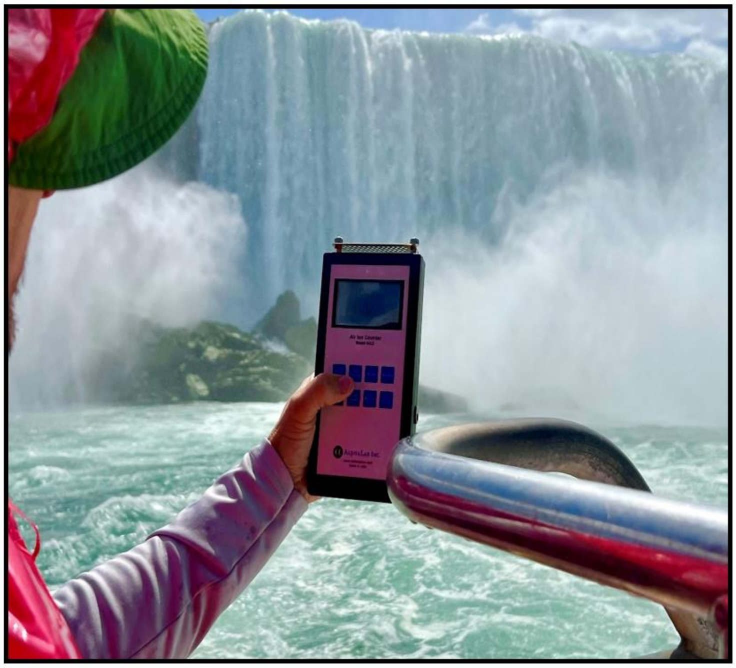

-29,860 ions/cc
Air Ion Counter
Model AIC2
AlphaLab Inc.
2

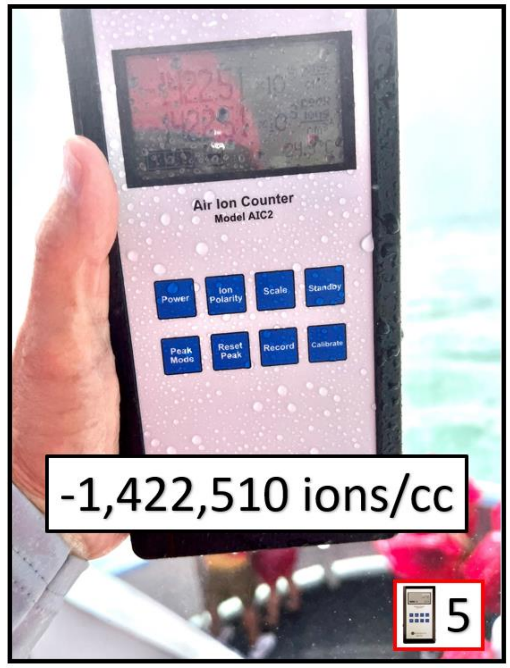



-70,270 ions/cc
Air Ion Counter
Model AIC2
3




-32,180 ions/cc
4

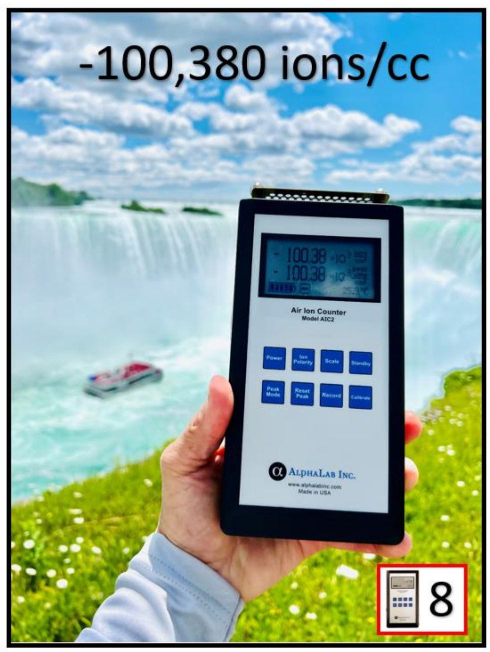



Air Ion Counter
Model AIC2
Power
Ion Polarity
Scale
Standby
Peak Mode
Reset Peak
Record
Calibrate
-1,422,510 ions/cc
5


-1,692,100 ions/cc
Air Ion Counter
Model AIC2
Power
Ion Polarity
Scale
Standby
Peak Mode
Reset Peak
Record
Calibrate
AlphaLab Inc.
www.alphalabinc.com
Made in USA
6


-44,840 ions/cc
Air Ion Counter
Model AIC2
Power
Ion Polarity
Scale
Standby
Peak Mode
Reset Peak
Record
Calibrate
AlphaLab Inc.
7


DANGER

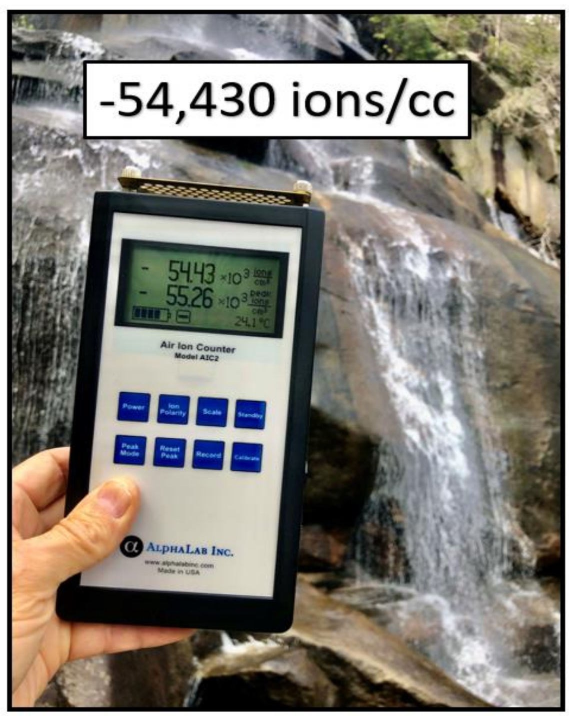

-100,380 ions/cc
Air Ion Counter
Model AIC2
Power
Ion Polarity
Scale
Standby
Peak Mode
Reset Peak
Record
Calibrate
AlphaLab Inc.
8

Ions and Humans

Ions occur naturally and in abundance in the air around us. While a variety of physiological or health effects in relation to exposure to air ions have been reported through the years, more recent research has posed doubt to these claims. The Journal of Negative Results in Biomedicine published a study in which the authors stated that from a mechanistic or physical perspective there is no basis to suspect that electric charges on clusters of air molecules (ions) would have beneficial or deleterious effects on respiratory or biological function. Their conclusion upon review of 80 years' worth of scientific literature, all of which had asserted the impact of human exposure to air ions and their effect on respiratory and other biological effects, was as follows: "Despite numerous experimental and analytical differences across studies, the literature does not clearly support a beneficial role in exposure to negative air ions and respiratory function or asthmatic symptom alleviation. Further, collectively, the human experimental studies do not indicate a significant detrimental effect of exposure to positive air ions on respiratory measures. Exposure to negative or positive air ions does not appear to play an appreciable role in respiratory function."

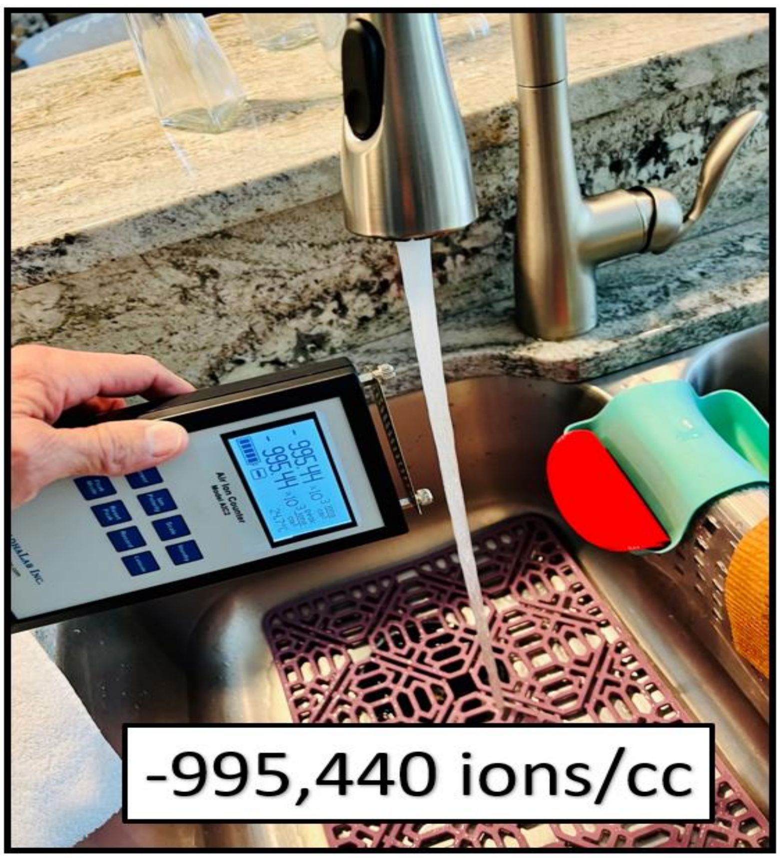
What Measurement at Niagara Falls has Demonstrated

Today I set a new personal record for the highest air ion concentrations measured outdoors. My past record was approximately -55,000 ions/cc at a waterfall in North Carolina where I live. I challenge anyone to try and break the counts recorded during my latest visit to the falls. If you do, please let me know.



While certainly not what I consider a controlled scientific experiment, what was accomplished has its place. I believe this a practical, real-world observation (through measurement) that helps quantitatively validate the Lenard effect. It demonstrates the impact this phenomenon plays in the creation of naturally occurring air ionization, and undoubtedly positions Niagara Falls as a behemoth in this realm. These findings help substantiate previous scientific study relative to the subject where field measurements may have not been made, or modern measurement apparatus was not available. This is more than I set out to out to accomplish, and I'm pleased with the results.

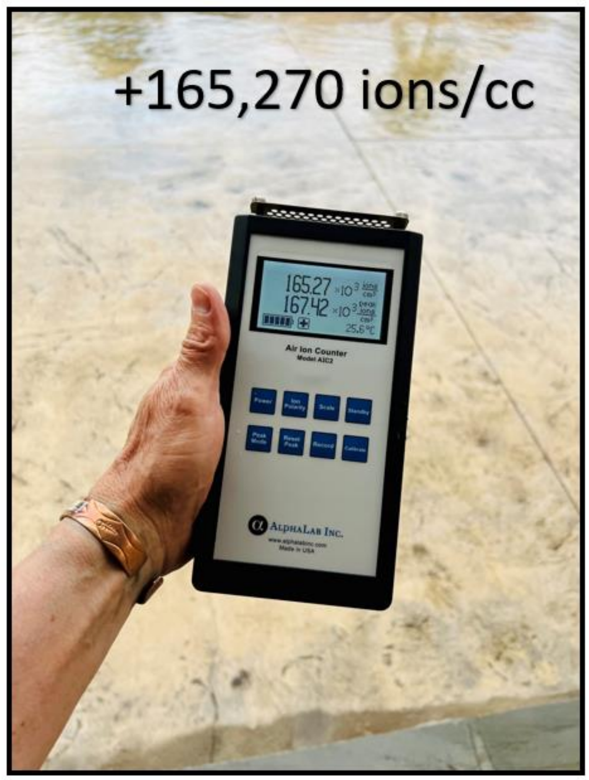
If you follow science, enjoy nature, and take joy in validating the combination of the two (like I do) I highly recommend you make the modest investment in a handheld ion counter and then embark on your own adventures to see firsthand how capable this world is of surprising us. It's absolutely amazing!



Fun ion fact #1: You can make your own mini-Niagara Falls and measure ions at home. Any source of fresh running water is subject to the physics behind the Lenard effect. All you need to do is open a faucet, turn on your hand-held ion counter, and you too can witness the considerable ion concentrations generated into the air surrounding the waters stream.

Fun ion fact #2: The reason we smell ozone outdoors during lightning storms is because it's a high-energy source of ion generation (hard ionization). When lightning heats the air, it splits the bonds between its molecules, and that's when random N and O atoms start "hoping-around" (electrical excitation). Most of the atoms pair back up once the air cools, but some reshuffle, so that some of the fractured atoms combine with O2, producing O3 (ozone).

Fun ion fact #3: You can also take air ionization measurements at home, during weather events such as rain or thunderstorms. The pictures below were taken on my front porch in Asheville, NC. during one such occurrence. Note that prior to the storm, outdoor background air ion concentrations were approximately (-)2500 and (+)1600 ions/cc, based on measurements taken earlier in the day.



About the Author:

David Schurk DES, CEM, LEED-AP, CDSM, CWEP, SFP, CIAQM, CHC, is Director-Healthcare and Applied Engineering Markets for GPS Air in Charlotte, NC. He has over 40-years of experience in the design and analysis of heating, ventilating, and air-conditioning systems for a variety of market sectors, with a special focus on healthcare and aerospace environmental control and air quality. He can be reached at dschurk@gpsair.com or 920-530-7677.

This paper is dedicated to all the science-seekers and ion-hunting enthusiasts out there, like me.