

# Cleaning Indoor Air using Bi-Polar Ionization Technology

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Clean air, both outdoors and indoors, is an essential determinant of a healthy life and a person's well being.

**Outdoor Air Quality (OAQ):** The federal government has made great progress towards cleaning outdoor air since 1970 via the Clean Air Act (CAA) and its additional amendments signed into law in 1990. This Act resulted in a significant 70% reduction of aggregate emissions of six representative indicators of common pollutants between the years of 1970 to 2014! Thusly, the CAA laws define the EPA's responsibilities for protecting and improving the nation's outdoor air quality utilizing the advances in science and technology to accomplish this task (1). These outdoor air quality improvements have enabled many areas of the country to meet national air quality standards set to protect public health and the environment. To simply summarize: for more than 40 years the CAA has significantly cut outside air pollution even as the U.S. economy has grown. Because of the act, Americans breathe less outdoor air pollution and face lower premature death and other adverse health effects (1).

**Indoor Air Quality (IAQ):** Despite public health awareness and progress on outdoor air pollution, progress on indoor air pollution has significantly lagged behind. The quality of air inside homes, offices, schools, day care centers, hospitals and other health care facilities (where multi-drug resistant bacteria reside), as well as other private and public buildings where people spend a large part of their life, is also an essential determinant of health and well being. Interestingly, indoor air quality is profoundly important for two main reasons. First, most Americans spend about 90% of their time indoors! Second, the EPA has reported that indoor air pollution is 25 to 100 times worse than the outdoor air. However there are some standards for indoor air. For example, if you work with certain chemicals, sprayed substances, powders or known carcinogens or allergens, the Occupational Health and Safety Administration (OSHA), the EPA of the workplace, requires employers to reduce risk for workers (2). The EPA has also developed some additional IAQ tools for schools (3). Certainly also the WHO (World Health Organization) has a long tradition in synthesizing the evidence on the health aspects of air quality and in providing air quality guidelines defining conditions for healthy air (4). IAQ is a term, which refers to air quality within as well as around buildings and structures, especially as it relates to the health and comfort of the occupants (5). IAQ is affected by gases (such as carbon monoxide and carbon dioxide), volatile organic compounds (VOCs), particulates, microbes (including bacteria, viruses and mold fungi), allergens, odors of a variety of types, and anything else that might affect the quality of the air.

**How We Make Each Other Sick:** There are available techniques for cleaning indoor air, but in order to better understand these options it is imperative to first discuss the dynamics of how we make each other sick. The great majority of human infections, about 80%, are transmitted by direct and indirect contact, and the remaining 20% of infections are transmitted by 3 other modalities, namely, common source (contaminated food or drink), arthropod vectors (such as

mosquitoes and ticks), and true airborne droplets (particles 5 micrometers or less, which is 5 millionths of a meter in size, and which do not readily drop to the affect of gravity. Infections such as tuberculosis, SARS and influenza can be spread in this way) (6).

**Contact Spread:** For contact spread the perspective host must have actual contact with the source of germs. Such contact can be direct, indirect or via aerosol droplets. An easy to understand example of **direct contact** is shaking hands or kissing someone who has a cold, which can easily spread that cold virus to you. Coughing, sneezing or talking (**are aerosols** which usually spread *within a few feet from the source and the victim*) in the face of another person in close proximity can also spread their germs directly to that person. On the other hand, **indirect contact** spread is distinguished from direct contact transmission by an intermediate object, usually an *inanimate object (fomite)* like a doorknob or other surface that a contagious person has touched or contaminated very recently, then afterwards, you touch it and then touch your eyes, nose or mouth or an opening in the skin which are the conduits of entry into your body.

**Airborne Spread:** Airborne spread implies the spread of germs *over a distance of more than several feet between the source and the victim*. The infectious organisms are usually contained in *droplet nuclei*, which are 5 micrometers in diameter (5 millionths of a meter) or smaller in size. These particles can remain suspended in air for hours or days and do not easily fall to the forces of gravity. The classic example of airborne spread is the transmission of the tuberculosis bacillus by means of droplet nuclei. Another organism spread via airborne is influenza, and yet another virus called SARS. We also learned in the post-911 anthrax attacks on NYC and elsewhere that the spores of anthrax also travel well in the air and can be kicked-up, so to speak, in particles and dust (6).

**Allergens:** Recently there was a report of a leaky dust filled vacuum cleaner, contaminated with Salmonella, which got re-suspended in the air each time the vacuum cleaner was turned on thereby infecting and re-infecting the household members. What is important to understand is that dust particles can carry germs but they can also carry allergens. According to the CDC allergies are the 6<sup>th</sup> leading cause of chronic disease in the U.S. at a cost of about \$18 Billion all told. An interesting statistic often quoted is that the average 1500 sq. ft. house accumulates about 40 pounds of dust over a year. And there are approximately 40,000 dust mites and debris that are contained in every ounce of dust. Breathing in such air can exacerbate existing allergies including asthma. Some ill health effects may show up shortly after a single exposure to pollutants in indoor air while some people can become sensitized to biological or chemical pollutants after repeated exposure. Other ill health effects may show up either years after exposure has occurred, or after repeated periods of exposure to poor indoor air quality (6).

**Greatest Risks:** Anywhere there is a building or facility that houses numerous people over an extended period of time, there is an unquestionable need to provide and/or maintain the quality of the indoor air. This is especially so for hospitals, medical centers, and other medical facilities, because this is where most of the antibiotic resistant bacteria reside and where many sick people are housed. As previously mentioned 80% of all infectious diseases are transmitted by direct and indirect contact. This issue is especially important in hospitals where caregivers can contribute to unnecessary illness and even deaths. According to the CDC there are almost a million nosocomial (hospital acquired) infections that occur every year as well as about 75,000 deaths from these infections at a cost to society of about \$4 billion annually (7). Nosocomial infections, especially those caused by highly antibiotic resistant germs, kill more people every year than pancreatic cancer, leukemia, multiple sclerosis, Parkinson's disease, and Alzheimer's combined. These diseases are the subjects of large public-relations campaigns to raise

awareness and solicit funds to combat them. Yet nothing as robust exists for nosocomial infections. Certainly antibiotics have saved millions of lives over the past 65 years or so, and will save countless others in the decades to come but in one sense the world's antibiotic use has been a 65 year experiment in self-sabotage. The selective ability to develop antibiotic drug resistance has allowed us to create more and more dangerous germs. Misuse of wonder drugs has created superbugs. Nowhere are superbugs more prevalent than in hospitals and medical facilities (6). It is of the utmost importance to prevent infection in anyway and everyway we can (including use of advanced technology that can maintain *indoor air quality*), so as not to be faced with a treatment dilemma.

**Available Techniques for Purifying and/or Positively Affecting Indoor Air Quality:** There are currently several technologies on the market that are useful to varying degrees for the purification of air and the maintenance of IAQ, allowing for reduction of infectious agents such as bacteria, viruses and fungi, as well as reduction in allergens and other particulates, especially useful in hospitals and other medical facilities. If we can greatly reduce or prevent an infection from occurring, we do not have to worry about antibiotic resistance or other problematic aspects of treating them. In a similar way reducing or eliminating allergens may more positively affect the 6<sup>th</sup> leading cause of chronic disease in the U.S. –allergies and asthma. These IAQ purification techniques are listed as follows in order of decreasing efficacy: Bi-Polar Ionization, PCO/PCI (photo-catalytic oxidation) technology, Needle-point Ionization, HEPA Air Filters, UV Light, Electrostatic precipitation. Of the aforementioned, there is only one technology that satisfies all of the tenants for providing clean indoor air quality for an entire building, which uses low energy, is effective against bacteria, viruses, and mold fungi (whether in air or on surfaces), neutralizes particulates, breaks down VOCs (Volatile Organic Compounds) eliminates unpleasant odors, eliminates static electricity, and produces no chemical or harmful by-products (including NO ozone production) and this is accomplished by the production of positive and negative ions (bipolar ionization). That system is AtmosAir Bipolar Ionization.

**Bipolar Ionization:** Bipolar ionization is created when an alternating voltage source (AC) is applied to a special tube with two electrodes. When voltage is applied to the tubes electrodes (like electricity is applied to a light bulb's filament) an ionization field is produced around the tube (just as light is produced from the light bulb). However the ionization cannot be seen but its presence will result in "mountain air" freshness. Such ions occur naturally especially on mountain tops and waterfalls, where the production of both positive and negative ions purify the air. Such a system has significant commercial and industrial applications. The airflow distributes the energized ions into all spaces served by the duct system in an in-duct installation or into the application space if a standalone is used. The beauty of the AtmosAir system is just how easily it integrates into existing commercial and residential HVAC systems. Unlike most air purification systems AtmosAir seeks out particulates and contaminants, including germs and does not wait for pollutants to find their way into the filter within the air handler. Instead **charged ions go to the contaminants in the space where you breathe, just as in nature, and do so in a continuous fashion and with continuous disinfection.**

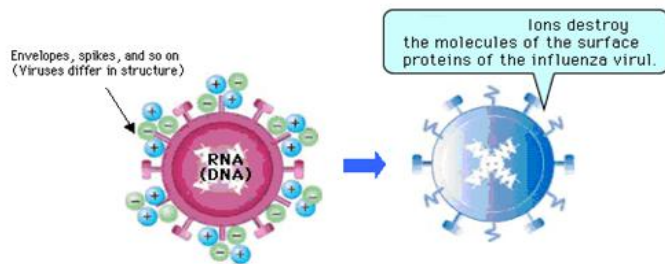
These positively and negatively charged ions have an effect on dust particles, allergen VOC's, odors, and bacteria, viruses, molds and mold spores. For example, regarding particles--- oppositely charged ions cause particles to attract to other particles and become bigger and heavier, by a process called "**agglomeration**". These bigger heavier particles can now be better trapped by HVAC system filters so the filters operate more efficiently. Also

many small particles that are generated within a space by people and their activities may never get to system filters and ordinarily stay suspended in air for long periods and can be breathed in, increasing the chance of illness and respiratory distress. The **bi-polar ion process will drop these to the floor quickly taking them away from where we breathe.** VOC's or gaseous chemical off gasses typically cause odors and irritations. These are also a major source of "Sick Building Syndrome" complaints, where people feel ill at work but feel better when they leave the building. **Bi-Polar ions break down hydrocarbon chains** that make up these complex compounds into immeasurable levels of carbon dioxide and water vapor. On micro-organisms like bacteria, virus and molds, **bi-polar ions will interrupt the reproductive ability of these organisms** so rather than colony forming units (cfu) increasing and spreading and expanding, they shrink away and lessen the chance of infection.

### **The Effect of Bipolar Ionization generators on microorganisms:**

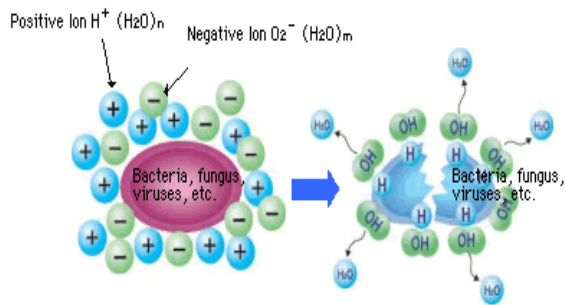
The negative and positive ions that are generated by BPI are designed to treat and allow energy imparted by the ions to transform ordinary oxygen into Reactive Oxygen Species (ROS), Superoxides, Peroxides, and Hydroxyls. These ions have the property of clustering around micro-particles, and thus, they surround harmful substances such as airborne mold, viruses, bacteria and allergens. At that point, a chemical reaction occurs on the cell membrane surface, and they are transformed into OH radicals, which are powerfully active (Standard Oxidation Potential [V] = 2.81 for OH vs H<sub>2</sub>O<sub>2</sub> = 1.78 and O<sub>2</sub> = 1.23) and because they are unstable they rob the harmful substance of a hydrogen atom (H). The result is that they are inactivated by severing the protein on cell membrane, which causes the opening of holes, thusly destroying the entity. The OH radicals instantly bond with the removed hydrogen(H), forming water vapor (H<sub>2</sub>O) which returns to the air. It is most important to note that bipolar ionization kills microbes without damaging DNA (therefore it does not cause cancer) in the interior of cells and unlike other physical and chemical agents, such as UV light, radioactivity and use of caustic chemicals, BPI is totally GREEN and it does NOT adversely affect the environment in any way.

*See the figures below, which pictorially help explain this process:*



#### Mechanism for Inactivating Airborne Virus

*The positive (H<sup>+</sup>) and negative (O<sup>2-</sup>) ions surround the hemagglutinin (surface proteins that form on organisms and trigger infections) and change into highly reactive OH groups called hydroxyl radicals (•OH). These take a hydrogen molecule from the hemagglutinin and change into water (H<sub>2</sub>O). The ions destroy the virus surface structure, for example its envelopes and spikes, on a molecular level. As a result, the virus cannot infect even if it enters the body.*



#### Mechanism for Inactivating Bacteria, Fungi

The positive ( $H^+$ ) and negative ( $O_2^-$ ) ions cluster together on the surface of airborne bacteria or fungi, causing a chemical reaction that results in the creation of highly reactive OH groups called hydroxyl radicals ( $\bullet OH$ ). The hydroxyl radical will take a hydrogen molecule from the cell wall of an airborne bacteria or fungi particle.

The Bi-Polar Ion technology accomplishes these benefits by sizing systems that consist of one or more bi-polar ion tubes, to the airflow rate of the HVAC system and the particulars of the space. The system then saturates the spaces with adequate quantities of bi-polar ions to ensure these reactions can occur. *See below some pictures of installed systems:*



One advantage to the way the bi-polar ion technology is applied is that it requires no re-engineering of the HVAC system, requires no continual adjustment or maintenance except a replacement of the bi-polar ion tube every 2 years.

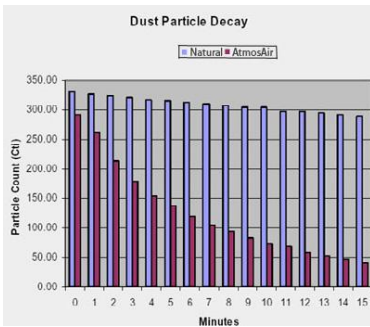
In laboratory testing bi-polar ion systems have shown significant contaminant reduction capabilities. The active process of the ions saturating the space to get to the source of contamination shows great efficiency when compared to passive technologies that must bring the contaminant to the device to be affected. *See the below chart of comparison testing of CADR rate (Clean Air Delivery Rate):*

Technology	CADR Rate
AtmosAir B-Polar Ionization	125
Lennox Photo Catalytic Oxidation	47.4
Honeywell Electronic Air Cleaner	35.8
Emerson Polarized Media Filter	27.2
Sharper Image Ionic Breeze	4.8
GPS Needlepoint Ionizer	1.3
Activetek PCO	-3.9

Source: Intertek ETL

Testing was performed to standard ASHRAE AC-1-2002. Testing rated relative performance on .3 micron particles in a standard 10"x10"x10' chamber.

Bi-polar ion systems have show good performance on dust particles, VOC's and micro-organisms both in air and on surfaces, see below some testing charts from this technology:



Source: Intertek ETL

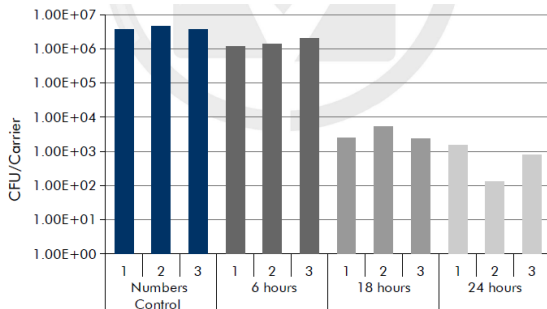
Testing was performed to standard ASNI/AHAM AC-1-2002. Testing showed performance on .3 micron particles in a standard 10'x10'x10' chamber. Without AtmosAir a 12.8% natural decay rate was measured while with AtmosAir supplying ions to the chamber an 85.8% decay rate was measured.

### AtmosAir TVOC Testing

Test Site	Percentage Reduction
Kilroy Realty	79%
Hyatt Hotel	95%
Staples Center	90%
Santa Ana Schools	97%
USC	97%
Rivers Casino	90%

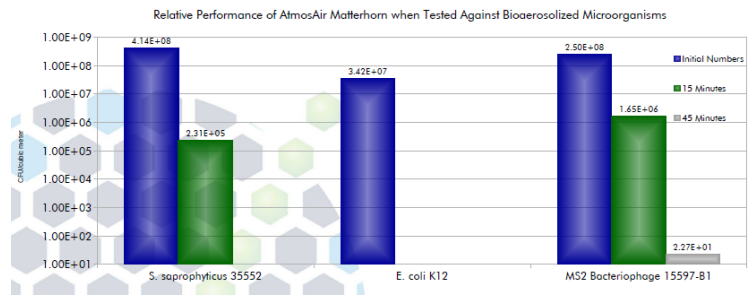
Source: Aircuity Inc, EMSL Analytical, Healthy Buildings International, DTS Environmental

TVOC levels as well as fixed gas levels were measured using Aircuity Optima monitors, EPA TO-15 and EPA TO-17 method analyzed by capillary gas chromatography and mass spectroscopy



Source: Microchem Laboratory, Round Rock, TX

*Clostridium Difficile* (C-Diff) was studied to see the affect of AtmosAir bi-polar ions. After 24 hours the percentage reduction was 99.98% when compared to the control group, a 3.64 log reduction.



Source: AntiMicrobial Test Labs, Round Rock, TX

*Staphylococcus Saprophyticus*, *Escherichia coli* and MS2 Bacteriophage were aerosolized in a test chamber and a control group and test group were studied. All three organisms showed a 99% reduction after only 15 minutes of exposure to AtmosAir bi-polar ions when compared to a control group

Combined with the ability to provide cleaner and healthier air is also the ability for **bi-polar ions systems to enable a building to save energy**. When air quality and the typical contaminants are considered and a proven strategy is used to control those contaminants (per ASHARE 62.1 IAQ Procedure) ventilation code required outside air introduction can be reduced and greater volumes of already conditioned air can be re-circulated. This allows a building's air handlers to cycle less and run for shorter durations and well as chillers and / or condensing units. This can **enable significant HVAC energy savings sometimes up to 20%** which, in turn, will impact the overall electrical and gas, oil or generated steam cost.

**This strategy has been proven in several studies. The US Army in a project co-sponsored by DOE conducted a study with bi-polar ionization** and reducing outside air need in a test building. The study concluded that a reduction of outside air from 40 cfm (cubic feet per minute) per person occupancy down to 5 cfm per person combined with bi-

polar ionization resulted in overall improved air quality in particles, spores and VOC levels while showing a reduction in HVAC power demand of 23%. This resulted in over 50 full-scale building integrations and growing. In a similar case study, **Staples Center in Los Angeles, CA studied bi-polar ionization** along with a strategy that included reduction of outside air by 50% and downsizing media filters from MERV 14 to 11. The study showed overall better air quality with particle and VOC reductions and HVAC power demand decrease of 21%. This study led to a full-scale integration of bi-polar ionization and reduced outside air and downsized filters throughout the entire arena. Because Bi-polar ionization will go to the source of contamination, a larger percentage of particles are affected than with filter systems. It has the effective filtering capacity of MERV 13 filtration without the static load on the air system.

### **Comparative Cost Savings and Simple Installation:**

The bi-polar ion technology can enable significant cost reductions when compared to the cost of HVAC equipment. Typically HVAC equipment costs approx \$1,500 per ton with a ton being equal to 400 supply cfm capacity or approx 400 square feet capacity so cost would be \$3.75 per cfm or square foot. A bi-polar ion system installed costs approx .80 per cfm or per square foot, so bi-polar ionization with its ability to reduce outside air and the tonnage needed to condition that air, provides a cost effective solution to providing good IAQ in buildings. Overall energy use in a typical building is 50% HVAC related and of that HVAC energy use is over 50% from having to condition outside air so the energy savings impact is substantial. Also bi-polar ion systems are very easy to integrate into new or existing HVAC systems. Systems can be easily installed into the main supply duct of the HVAC system so the bi-polar ion tubes can be inserted into the supply airflow and saturate the interior with bi-polar ions. A typical system that can serve up to 15,000 square feet can be installed in under an hour. Also the same system uses less than 50 watts of power to operate and imparts a negligible static pressure on the airflow, so these systems do not impose an energy penalty by their use as adsorbent technologies such as carbon filters or other types of air scrubber systems will by their operation. When compared to a high efficiency filter for cost of operation, AtmosAir systems will cost 90% less to operate due to the low airflow restriction and operating cost.

### **Some Additional Supportive Research**

As previously mentioned nosocomial infections in hospitals, especially with highly antibiotic resistant germs, infect about a million patients annually, killing about 75,000 of them at a cost of about \$2 billion. Several published studies have shown the usefulness of bipolar ionization controlling airborne bacterial populations. For example, there is ample evidence that airborne route of transmission is important in the epidemiology of several nosocomial bacteria including *Acinetobacter* spp infections (8). Multiple antibiotic resistant *Acinetobacter* spp have emerged as a significant health-care associated infection (nosocomial) and these microbes usually become endemic throughout the hospital (9). The above cited study reported that *Acinetobacter* spp cases were reduced from 11 to 2 ( $p=0.007$ ) using bipolar ionization. Further, this study reported that it is clear that ionization has a likely role in prevention of *Acinetobacter* infections (8).

There is growing evidence that bioaerosols can be generated in an indoor setting by ventilation or air conditioning systems, dust or shed skin disturbance, coughs, and sneezes among others (10, 11). Several other studies have demonstrated that hospital activities,

such as bed making, caused significant aerosolization of methicillin-resistant *Staphylococcus aureus* (12, 13). Even nurses polypropylene aprons, along with other plastic materials used in a healthcare setting generated static electric fields and collected high numbers of microbes (14). Another study reported that when surgeons perform endoscopic surgery they frequently point to a video monitor during the procedure and they found that bacteria grew when a gloved hand passed within 4 cm of the monitor but not beyond 8 cm distance (15). In another study, a 40-50 % reduction in microbial air pollution was found after employing a 13.5 kV corona-type ion generator every second week in a dental clinic (16). Similar types of studies have been conducted for non-biological particles in the semiconductor industry. Another major study evaluated the effect of surface charge and air ionization on deposits of airborne bacteria (17). They found that implementation of bipolar ionization resulted reduction of bacterial deposition. This is important because static charges on fomite surfaces may attract resulting deposition in excess of that expected by gravitational sedimentation or simple diffusion (17). Their findings suggest that highly charged bioaerosols and materials used in patient setting may represent an important new avenue for exploration and research into reduction of hospital-acquired infections.

Airborne movement of dust, and other particulates has frequently been implicated as a potential mechanism for transmitting *Salmonella enteritidis* infection in poultry houses (18). In order to determine whether air ionization would affect airborne transmission of *S. enteritidis*, baby chicks were housed in four controlled-environment isolation cabinets in which airflow was directed across an unoccupied central area from one (“upstream”) group of birds to another (“downstream”) group (18). Ionizers were installed in two of the cabinets. In three replicate trials, groups of chicks were placed in the upstream end of the transmission cabinets and orally inoculated with *S. enteritidis* at one week of age. On the following day, 1-day-old chicks were placed in the downstream end of the cabinets. When chicks were sampled at 3 and 8 days post-inoculation, *S. enteritidis* was found on the surface of 89.6% of the downstream chicks from cabinets without negative air ionizers, but on only 39.6% of the downstream chicks in the presence of the ionizers. Most importantly, *S. enteritidis* was recovered from the ceca of 53.1% of sampled downstream chicks in cabinets without ionizers, but only 1 % of the ceca of chicks in cabinets with ionizers installed (18).

Studies of the effects of ionization on bacterial aerosols in a burns and plastic surgery unit were studied (19). It is known that the microbial contamination of the air in burn units is high (20). A classic study demonstrated in single rooms where isolated patients were nursed, the ionization experiments of 24 h periods with -5kV showed lower sedimentation bacterial counts during ionization on two repeated occasions (19). The total colony counts represent contamination due to staff and patients. Phage typed finger-printing of *Staphylococcus aureus* strains in the air indicate shedding by individual patients. Although the sheath bacteria-carrying epithelial cells is large, the number of *S. aureus* bearing particles was significantly decreased by ionization. Clearly the number of *S. aureus* shed by patients in presented cases was also lower during the ionization (19). In a similar study, researchers performing experiments with animal respiratory diseases caused by Newcastle disease virus suggested that contamination of the air by droplets that carry other bacteria like *Mycobacterium tuberculosis*, *Mycoplasma pneumonia*, and other microbes (like *Legionella pneumophila*), may also be prevented by ionization of the air (21). They suggest that ionization of air may prove to be an alternative to increased air ventilation and filtration (21).



Air ionization has a long history of varied applications. In one published review article on the ionization of air for removal of “noxious effluvia”, a presentation of recent developments in the application of controllable air ionization processes that apply dielectric-barrier discharge devices to generate non-thermal plasmas have led to applications for chemical and biological decontamination in indoor environments (22). These include significant reductions in airborne microbes, neutralization of odors, and reduction of VOCs. Also removal of very fine particulates (PM<sub>x</sub>) is also enhanced by air ionization. The physics and chemistry of air ionization, and its utility for contributing to significant improvements in indoor air are discussed in detail (22).

The efficacy of bipolar ionization technology against a wide variety of pathogens was confirmed through collaborative research (23). Efficacy in inhibiting of airborne target substances noted below was verified by exposing those organisms to an ion concentration of at least 3000 ions/cm<sup>3</sup>. Effective kill was achieved in seconds to minutes dependent upon the microbe, the exposure time, and the concentration of ions. Studies have shown that a more rapid kill-time can be achieved by increasing concentration of ions. For example, Sharp Corporation studies in collaboration with Retroscreen Virology Ltd demonstrated that the highly pathogenic H5N1 avian influenza virus could be inactivated by 99.9% in ten minutes using a high bipolar ion concentration of 50,000 ions/cm<sup>3</sup> (24). Sharp has also shown that reduction by 99% could be achieved in ten minutes at a concentration of 7000 ions/cm<sup>3</sup> (24). It is very important to understand that during actual real-time in-use conditions, bipolar ionization systems perform in a continuous steady fashion with continuous disinfection so that large bolus concentrations are unnecessary for effectiveness.

The results of a series of studies are summarized in the chart below (23, 24):

John Oxford's Efficacy of Bi-Polar Ionization on Various Pathogens		
Target Substance	Species	Testing and Verification Organization
Fungi	Cladosporium (black mold, mildew)	Ishikawa Health Service Association Universitätsklinikums Lübeck University Clinic (Germany) (proliferation control effect) CT&T (Professor Gerhard Artmann, Aachen University of Applied Sciences)
	Penicillium, Aspergillus	Universitätsklinikums Lübeck University Clinic (Germany) (proliferation control effect)
	Aspergillus, Penicillium (two species), Stachybotrys, Alternaria, Mucorales	CT&T (Professor Gerhard Artmann, Aachen University of Applied Sciences)
Bacteria	Coliform bacteria (E. Coli)	Ishikawa Health Service Association
	E. coli, Staphylococcus (aureus), Candida	Shanghai Municipal Center for Disease Control and Prevention, China
	Bacillus subtilis	Kitasato Research Center of Environmental Sciences CT&T (Professor Gerhard Artmann, Aachen University of Applied Sciences)
	MRSA (methicillin-resistant Staphylococcus aureus)	Kitasato Research Center of Environmental Sciences Kitasato Institute Medical Center Hospital
	Pseudomonas, Enterococcus, Staphylococcus	Universitätsklinikums Lübeck University Clinic (Germany) (proliferation control effect)
	Enterococcus, Staphylococcus, Sarcina, Micrococcus	CT&T (Professor Gerhard Artmann, Aachen University of Applied Sciences)
Viruses	H1N1 influenza virus	Kitasato Research Center of Environmental Sciences Seoul University, Korea Shanghai Municipal Center for Disease Control and Prevention, China Kitasato Institute Medical Center Hospital
	H5N1 avian influenza virus	Retroscreen Virology, Ltd.
	Coxsackie virus (summer colds)	Kitasato Research Center of Environmental Sciences
	Polio Virus	Kitasato Research Center of Environmental Sciences
	Corona Virus	Kitasato Institute Medical Center Hospital
Allergens	Mite allergens (dead bodies and feces)	Hiroshima University
	Pollen	Hiroshima University

Air ionization, although historically well documented and technologically well advanced, is just now entering the field of treatment of specific targets in indoor environments, which directly affect the IAQ and bring with it the potential for associated health benefits!

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