Ionization and Air Quality- A Technological Study

Ionized air molecules make up more than a very small percentage of the atmosphere. However, despite their small numbers, these molecules play a profound role in maintaining the health of the atmosphere by removing particulate and chemical pollutants. In the indoor environment, ionization provides an even wider spectrum of benefits, including the destruction of bacteria and elimination of odors. However, conventional construction and ventilation techniques tend to negate the benefits of ionization. This problem can be mitigated by technology designed to augment the ionization of indoor air.

Natural Sources of Atmospheric Ionization

A small number of natural processes contribute a constant supply of ionization to our atmosphere. These natural sources of ionization include (1) the effects of radiation, (2) effects of the earth's electric field, (3) the movements of wind, and (4) the splashing of water (Lenard Effect).

The decay of naturally occurring terrestrial radioactive materials; radiation from the sun and cosmic radiation, all cause ionization in the atmosphere by stripping electrons from air molecules. The molecules effected in this way become positive ions due to the loss of electrons. The free electrons immediately get picked up by the surrounding neutral molecules, which thus become negative ions (Sulman, p. 102).

The electric field of the earth causes ionized molecules to gain kinetic energy as they move along the 400,000-volt gradient that exists between the ionosphere and the surface of the earth. When a fast moving ion collides with a neutral molecule, the neutral molecule loses one or more electrons. The loss of electrons causes the neutral molecule to become a positive ion. The electrons knocked free during the collision are immediately picked up by surrounding neutral molecules; resulting in new negative ions (Jokl, p. 268).

Winds and weather are a large source of ionization. The movement of weather fronts produces great amounts of ionization through friction. Air masses moving against the earth, or against other air masses cause a transfer of electrons, and thus ionization (Sulman, p. 245).

Falling water also produces ionization. Whenever water droplets collide forcefully, small particles separate from the water surface carrying a negative charge into the atmosphere. The larger water droplets and the main body of water become positively charged. This phenomenon, named after its discoverer, is called the Lenard Effect (Jokl, p. 278).

All sources of ionization have the effect of electrifying the atmosphere. The electrical charge of the atmosphere at any location on the earth's surface (aside from human factors) depends upon the productivity of these natural sources of ionization. The prevalence of either negative or positive ionization in any location will have an impact on the health of the animals, plants, and humans living in the area.

Effects of Negative Air Ionization

Anecdotal evidence for the helpful effects of ionization extend as far back as the 18th century. According to Krueger, more than two centuries ago Father Giambattista Beccaria of the University of Turin observed, "It appears manifest that nature makes extensive use of atmospheric electricity for promoting vegetation." And I'abbe Bertholon suggested the idea that "electricity in the air influences the state of health and the cause of disease in animal and man" (Krueger, p. 2)

In the second half of the 20th century studies began to appear specifically stating the helpful biological effects of negative air ions. According to Pogrund (Sulman, p. 165), the reported physiological effects of negative air ionization include:

1. Decreased respiratory rate
2. Decreased basal metabolic rate
3. Decreased blood pressure
4. Produced a feeling of well being
5. Increased vital capacity
6. Decreased skin temperature
7. Acceleration of the conversion of succinate to fumerate
8. Stimulation of cytochrome
9. Decreased eosinophilia and lymphocyte count
10. Increased CO_2 combing power of plasma
11. Decreased blood sedimentation rate
12. Decreased muscle chronaxie
13. Increased ciliary activity
14. Increased frequency of mitosis
15. Increased resistance to infection
16. Suggested as therapy in chronic rhinitis, sinusitis, migraine, insomnia, tuberculosis, wound and burn healing, asthma, hay fever, emphysema, bronchitis, conjunctivitis, chlorine gas poisoning, preventing thromboembolism.

In studies conducted by the Air Ion Research Laboratory at the University of California, evidence show that negative air ions kill many forms of molds and bacteria. The microorganisms eliminated by negative ionization include those that cause cholera and typhoid fever (Krueger, p. 4).

Negative ionization also appears to promote plant growth and shorten the time required for some plants to reach maturity. Reduction of negative ions is reported to decrease growth rates and cause the same plants to droop (Krueger, p. 4).

There is an established link between negative air ionization and the fluctuation of seratonin levels in humans and animals. Among other functions, seratonin causes the smooth muscles of the respiratory system to contract (Jokl, p. 238, Sulman, p. 162). Negative ionization has been shown to decrease seratonin; however, positive ionization increases seratonin levels (Kreuger, p. 5).

Negative ionization also has the effect of cleaning the atmosphere by removing particulate and chemical pollutants. As negative ions move through the air, they convey their electrical charge to dust, smoke, and water particles. The negative charge causes these particles to clump together and eventually drop to the ground (Sulman, p. 245).

The mechanism by which negative ions break down chemical pollutants is slightly more complex. The principle at work is summarized by the following maxim found in basic chemistry textbooks, "Negative ionization will reduce hydrocarbons and their derivatives to the common denominators of water, carbon dioxide, and any metal oxide." For example, when formaldehyde (CH_2O) is exposed to negatively ionized oxygen molecules, it initially breaks down into water (H_2O) and carbon monoxide (CO). With continued exposure to the negative oxygen ions the carbon monoxide (CO) becomes further oxidized, transforming it into carbon dioxide (CO_2).

This characteristic of negative ionization is also responsible for the added benefit it provides of elimination of odors. Odors result from the presence of particular molecules in sufficient number to reach the threshold of human olfactory sensation. As described above, negative ionization breaks down "hydrocarbons and their derivatives." Most odor-causing molecules fall into this category.

Effects of Positive Air Ionization

Whereas negative ionization is generally considered to be beneficial, positive air ions appear to cause harmful effects (Sulman, p. 160). According to Pogrund (Sulman, p. 165), the reported physiological effects of positive air ionization include:

1. Inhibition of growth of tissue cell cultures
2. Increased respiratory rate
3. Increased basal metabolism
4. Increased blood pressure
5. Produced headache, fatigue, nausea
6. Produced nasal obstructions, sore throat, dizziness
7. Increased skin temperatures
8. Depressed rate of ciliary activity
9. Increased muscle chronaxie
10. Altered alpha wave of the EEG
11. Reduced succinic oxidase activity in the adrenals
12. Increased the blood level of 5-hydroxytryptamine

When positively ionized oxygen molecules are inhaled they have a very strong effect on lung function. Positively charged oxygen ions cause a reduction in respiratory capacity, which results in diminished resistance to stress and reduced mental ability (Sulman, p. 339).

Positive ionization in the atmosphere results in part from the collisions of normal air molecules with dust particles and by friction between different cloud layers. Positive

ionization always precedes certain types of weather fronts by one or two days, because electricity moves faster than the weather that generates it (Sulman, p. 339).

The problems of positive ionization are also associated with the phenomena known as "evil winds" such as the *sharav* in Israel, the *foehn* in Europe, and the *Santa Ana* winds in southern California (Sulman, p. 341). Effects associated with these winds include stress reaction, thyroid problems, breathing difficulties, disrupted biorhythms, and an increase in aches and pains (Sulman, p. 144).

People who are especially sensitive to weather suffer the most from the effects of positive ionization in the atmosphere. Weather-sensitive people comprise approximately 30% of the general population.

In addition to the effects of wind and weather, positive ionization also dominates under conditions of foggy and/or polluted air. Particulate suspended in the air usually carries a positive charge. Stagnant, hot, summertime air in the vicinity of large cities can produce a "degree of static foehn", which brings the same unhealthful effects as any other large source of positive air ionization (Sulman, p. 341).

Ionization and the Indoor Environment

The acceptable minimum concentration of negative ions for indoor air is 200-300 ions per cm3. The optimal level is 1000-1500 negative ions per cm3 (Jokl, p. 289). However, the reality is that the concentration of negative ionization in the outdoor air is sometimes far below this acceptable minimal value, especially in cities. The situation is worsened by the fact that many characteristics of the indoor environment have the effect of reducing the amount of naturally available ionization.

The walls of buildings tend to decrease and even eliminate the normal atmospheric ionization. Walls constructed using wood or brick cause only a small reduction in atmospheric ionization. However, walls made of steel or of iron and concrete, create a Faraday cage effect around the enclosed space, shielding the interior from the outside ionization (Jokl, p. 274). As discussed earlier, ionized air molecules will help eliminate chemical adn particulate pollutants from the indoor air, however, the greater the volume of pollutants the more the ionization is reduced.

Ventilation, heating, and air conditioning systems also reduce air ionization. The effect of propelling air through metal ducts reduces negative ionization at a loss of 20% every two meters (Jokl, p. 276). This process also produces a lot of positive ions. These effects are made worse with drier air and warmer ducts (Sulman, p. 105).

Human occupancy further diminishes the supply of negative ionization in indoor air. Human activities introduce particulate and chemical pollutants, as well as microbes to the indoor environment. Additionally, all sources of fire (even the burning of natural gas) (Sulman, p. 106), and especially cigarette smoking (Jokl, p. 276), directly add large quantities of positive ions to the indoor air.

Together, these indoor environmental factors contribute not only toward a decrease in the naturally available negative ionization, but at the same time significantly increase the pollutants, microbes, and odors present in the enclosed atmosphere.

A solution that addresses all these problems is technology designed to augment the negative ionization in the air. Such devices have existed since the early part of the 20th century, however, not without two bothersome side effects.

The most troubling side-effect of many machines designed to create negative ions is that they also create ozone (O3). Although small amounts of ozone occur naturally in the atmosphere, in sufficient quantity its effects are toxic to humans (Sulman, p. 106).

RC Enterprises of Chico, California has designed, patented, and produces devices which generate negatively ionized oxygen molecules while avoiding the problems of creating ozone or plating the wall with dirt. The solution utilizes electrical fields to generate a low-energy stream of electrons while a steady flow of air passes perpendicular to the orientation of the electric field. A portion of the passing air molecules pick up electrons as they move across the electrical field, thus becoming negatively ionized. This process is referred to as cross-field gas ionization (Huggins).

As of this date, cross-field ionization machines have been continuously in service for more than 10 years. Their primary application has been in supermarkets where they are installed adjacent to fish counters. In this application, more than 1,000 cross-field ionization machines are already being used to eliminate odors and significantly reduce bacteria in the indoor environment.

Conclusions

Ionization is part of a healthy atmosphere. It is one of nature's tools for maintaining and cleaning the air. Though positive and negative ionization exist together naturally in the atmosphere, and abundance of negative ionization appears to have very beneficial effects on humans, animal, and plants while an abundance of positive ionization seems to be detrimental.

Human activities tend to decrease the amount of negative ionization in the atmosphere. The problem is only greater when examined in the context of the indoor environment, especially if one considers how much time the average city-dweller spends breathing indoor air.

Technology designed to generate negative air ions can appropriately address many issues related to indoor air quality, provided that such technology already exists; although up to the present time it has been employed only in one primary application. With a wider dissemination of this information, perhaps a wider range of indoor environments will realize benefits from this technology.

References

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Abstract: Atmospheric ionization as related to the indoor and outdoor environments. Benefits of negative ionization are discussed. Patented solutions by RC Enterprises (Chico, California) generate negatively ionized oxygen molecules, improving indoor air quality without creating ozone and without plating interior wall with dirt.