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Air Ions and Human Comfort

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Since the discovery of electricity man has speculated on the effect of the electrical condition of the atmosphere on his health and comfort. The oppressiveness that people feel before a storm, the exhilaration experienced after it has passed, the feeling of the freshness of mountain air and, conversely, the ill effects of hot, dry wind were considered to be related to the state of electrical charges or ions in the air. Stuffiness indoors was also thought to be due, in part, to the ion content of the air.

Over the past fifty years interest in artificially altering the ion content of air for clinical treatment and human comfort has been surrounded by controversy, mainly because of the conflicting results obtained from various studies of the effects of air ions on comfort and health. Although the use of ion generators in heating and ventilating systems is not common at present, a resurgence of interest occurs from time to time. This Digest will review, very briefly, the current state of knowledge of air ions, both naturally and artificially produced, with particular attention to their possible effect on human comfort and health.

Nature of Air Ions

Several types of electrically charged submicroscopic particles - air ions - are found in the atmosphere. They may be atoms, molecules, a group of molecules, or particles such as dust or liquid droplets that have become electrically charged. If an atom loses an electron it forms a positive ion; if it gains an electron, and thus manifests a negative charge, it becomes a negative ion.

Ions are continuously produced in nature formed by the bombardment of air molecules by alpha and beta particles, by the absorption of radiation such as X-rays, gamma rays, cosmic rays and short-wave ultraviolet radiation, by the shearing of water droplets, and by drifting snow and dust. Such sources of energy dislodge electrons to form positive ions, and the free electrons are subsequently captured by other air molecules to form negative ions.

Although ions are continuously being formed, they are also neutralized by combination with ions of opposite polarity, so that their concentration in the atmosphere is fairly constant. Ionization due to cosmic rays and radioactive matter in soil is approximately constant with time at a particular location, but that due to radioactive material in the air varies because of air turbulence and because the rate of exhalation of radioactive gases from the soil is affected by such factors as temperature, wind, and ground covering.

Ions are classified not only by their electrical charge (polarity) but also by size as small, intermediate and large. Small ions, consisting of only a few molecules, are between 0.001 and 0.003 micron in diameter. Large ions are at least ten times the size of a small one and may be as large as 0.1 micron in diameter. A small ion is highly mobile compared with a large one, its velocity in an electrical field being about 5000 times greater than that of a large ion.

There is an additional physical difference between large and small ions. If a small one is neutralized, the molecules that have been held together by the charge move apart, leaving no trace of the original collection; if a large ion loses its charge, on the other hand, it continues to exist as an uncharged particle. The two classes also differ in length of life. The average time interval between formation and destruction of a small ion in clean air is about 4 to 5 min, in polluted air generally less than a minute. Large ions have a life of about 15 to 20 min in clean air and about an hour in polluted air.

Ion Measurement and Ion Generation

Measurement of ion density or ion concentration - the number of ions per unit volume of air - is made with an ion counter whose basic component is usually a cylindrical condenser arranged so that the air to be counted is passed between two concentric cylinders at a certain velocity. The ion counter does not count the number of ions directly, but collects them and measures the ion current to the condenser. From this the number of ions is calculated by assuming that each carries a unit charge. An ion counter can be designed not only to measure small or large ions but also to measure positive or negative ions simply by changing the polarity of the potential difference.

Machines for the generation of negative ions have been designed on several principles, including photoelectric effect whereby a metal, usually arranged as a screen surrounding an ultraviolet lamp, ejects electrons when acted upon by the lamp's radiation. The electrons attach themselves to particles in the air, which is blown over a screen by a fan. Some designers of negative ion generators have used the high-voltage corona discharge effect, involving the ionization of air surrounding an electrical conductor.

Because certain processes in the generation of negative ions may also produce products such as ozone, a gas toxic above a certain concentration, ion generators must be carefully designed and constructed for safe operation.

Ion Concentration in the Atmosphere

Ion concentration in the atmosphere differs widely from place to place; the number of small ions, for example, varies over a range of about 200 to 2200 per cm^3 depending on geographical location. There is normally a slight excess of positive over negative ions. In the relatively unpolluted air of the country and in urban areas where there is much vegetation, small ions dominate, whereas in heavily populated and industrialized areas large ions greatly exceed small ones. At high altitudes, because of strong ultraviolet and cosmic radiation, the concentration of small ions in the air is much greater than at sea level.

Ion concentration exhibits regular daily and annual variations; for example, in the daily cycle increased concentration of small ions usually occurs shortly after mid-day, and in the yearly variation, in the summer months. Changes in meteorological conditions have significant effects on the ion concentration of the air. In general, a drop in temperature and humidity is preceded or accompanied by a sharp rise in ion content. On cloudy days, ion concentration is usually less than that on clear days, while foggy weather further reduces it. The most striking weather effect is heavy rain, especially if it is accompanied by thunder; in such conditions the number of small ions, both negative and positive, increases greatly, as shown in Figure 1, which indicates the effect of various meteorological conditions. Figure 1 also demonstrates the seasonal effect on the concentration of small ions.

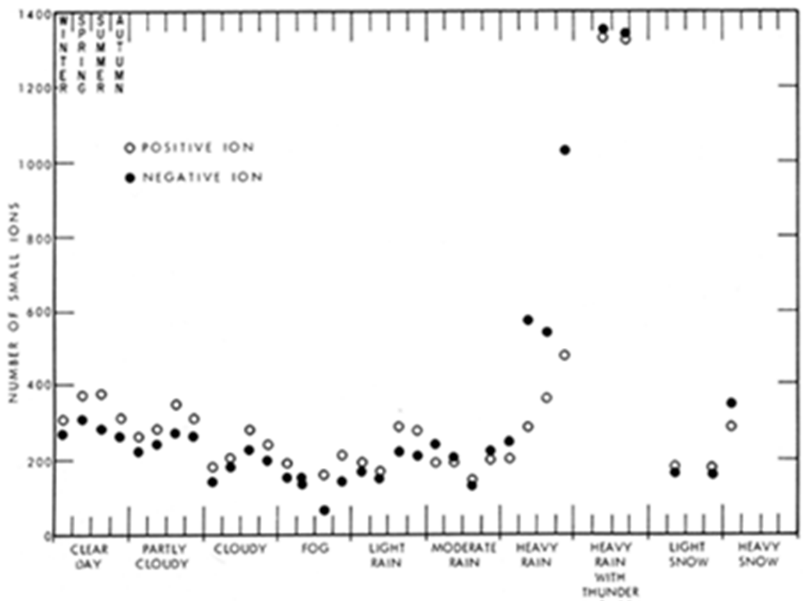

Figure 1. The effect of meteorological conditions on the number of small ions in the atmosphere (data from Yaglou, C. P., and L. C. Benjamin, ASHVE Transactions, Vol. 40, 1934).

Ion Concentration in Buildings

Ion concentration in unoccupied rooms with natural ventilation is not very different from that outdoors. When a room is occupied, however, the small ion concentration decreases sharply, the extent depending on the number of occupants and the density of pollutants such as tobacco smoke. Any decrease in small ion concentration is always accompanied by an increase in large ion concentration. This is brought about, in part, because small ions combine with the condensation nuclei given out with each breath, and with smoke particles, to form large ions. The decrease in the small ion content of an occupied room and the corresponding increase in the concentration of large ions takes place very rapidly, frequently within an hour, after which fairly constant levels of ion concentration are established. When the room is vacated, a slow recovery occurs over several hours, bringing the air back to its original ion concentration.

Certain components of air-conditioning systems also cause variation in the ion concentration in buildings, as shown by tests of an air-conditioned room whose ion content was not affected by the operation of an air-conditioning system without ductwork. When the conditioned air was forced through a long metal duct, however, there was a measurable small increase in the number of positive small ions. When an electric heater was turned on, the concentration of positive small ions in the test room quadrupled, until there were about three times as many positive small ions as negative small ions. If an air washer was turned on instead of the electric heater, the number of negative ions rapidly increased to a level five times as great as the previous concentration.

Effects of Air Ions

The first systematic study of air ions and their biological effect on humans, reported in Germany in 1931, involved tests of both healthy people and invalids. The results indicated that air ions of opposite charge had opposite effects: positive ions caused an increase in pulse rate, blood pressure and metabolic rate, resulting in unpleasant sensations such as headache, dizziness and fatigue; negative ions caused a decrease in these physiological functions, producing a feeling of well-being. These findings were naturally checked by other research workers, but their results were sometimes inconsistent or, in certain cases, negative.

Among the studies considered to have shown beneficial effects was one of individuals suffering from diseases of the respiratory tract; good therapeutic results were obtained with negative ions. In another, patients suffering from hay fever and asthma obtained temporary relief when exposed to negative ions, their symptoms recurring within a few minutes to 2 hours of their return to a normal environment. A study of the effect of negative ions on burn victims indicated marked improvement in the affected areas: relief from pain, reduction in malodour, and a somewhat shortened period of healing.

In several other studies the administration of positive or negative ions produced no changes in physiological function or subjective sensation. In some, in which the physiological response to positive and negative ions did not differ greatly, subjective sensations were favourable with negative ions and unfavourable with positive ions, but the preference for negatively ionized air was not strong enough to suggest a significant improvement except for abnormal subjects. Ionized air, however, irrespective of sign, appeared to exert a normalizing influence upon physiological functions above or below the norm.

Such inconsistent results have been attributed to a lack of standardized test conditions, in particular to differences in the methods of ion generation and measurements of ion concentration, dosage, and length and frequency of exposure. In some studies, for example, ion concentration of a few thousand per cm^3 was used whereas other researchers have employed much higher densities. The inconsistent results may also reflect differences in the response of individuals to air ions. Some people may be more sensitive to them than others. Those suffering some physical distress appear to be particularly sensitive to changes in air ionization.

Conclusions

Ions of various types, some small, some large, some carrying positive electrical charges, others negative, are present in the air. The nature and quantity vary with natural weather changes and fluctuations in cosmic and other radiation, as well as with building environment because of the occupancy and the operation of equipment such as heating and ventilation units. There is evidence that some control can be exerted within buildings by the use of ion generators.

It appears that the possible benefits of air ionization for normal subjects are of little significance, although there are some normalizing effects. There is appreciable evidence that the use of negative ions for some clinical treatments such as those for hypertension, asthma, hay fever and burns is beneficial; but there is also evidence of no effect.

As the effect of air ions on the comfort of anyone with normal health appears to have little or no practical significance, artificial ionization of air within buildings is not warranted. Unsatisfactory indoor air quality should be corrected by the proper application of the usual ventilation practices, including air filtration, adequate outdoor air supply, exhaust, and control of the production of air contaminants.