Comparison of Air Ion and Pollution Index Variation during Morning/Evening Period at Rural Station Ramanandnagar India

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***Abstract*-The atmospheric-electric processes can be understood only if it is assumed that the atmosphere is electrically conducting. The presence of aerosols in the air was found to be greatly affecting the air ion concentration. At rural station Ramanandnagar, there are numbers of sources for the production of air ions, at the same time there are limited sources for the production of aerosol in the atmosphere. Variations of air ions in atmospheric air have been investigated using Gerdien type air ion counter. This air ion counter indigenously designed and developed at the Indian Institute of Tropical Meteorology Pune and operated at rural site Ramanandnagar. During the morning period average positive air ions were $9x10^2$ ions per cm^3 in January 2012, they start decreasing and reaches to minimum ($1.2\ x10^2$ ions per cm^3) in April. Average negative air ions were $6x10^2$ ions per cm^3 in January during the morning period (06:00-08:00 hours). During evening period average positive air ions were $11x10^2$ ions per cm^3 in January 2012, starts decreasing and reaches to minimum ($1.8\ x10^2$ ions per cm^3) in April. Pollution index above 1.2 in January, May and August 2012 during evening period (18:00-20:00 hours), which is harmful to the human health.**

Keywords- Air Pollution; Air Quality; Aerosol; Transperation

I. INTRODUCTION

The atmospheric-electric processes can be understood only if it is assumed that the atmosphere is electrically conducting. The observation of the leakage of the charge through the air from an insulated electrified body led Coulomb [1] to the discovery that the air has a finite electrical conductivity. However, it was more than a century later, Wilson [2] discovered the existence of ions. Later experiments on the influence of aerosol in the air led to the conclusion that it was due to the presence of finely divided matter, liquid or solid, in the freshly prepared gas. The presence of aerosol in the air was found to be very greatly affecting the conductivity. Since the aerosol particles are very large compared to the ions, an ion is more likely to strike against aerosol-particle, and give up its charge to it or to adhere to the surface, than to collide with an ion of opposite sign. In this way, the rate of loss of air ion concentration is rapid.

Radiation from radioactive gases exhaled from the ground and their other daughter products causes ionization in the atmosphere. The radiations of α, β, and γ released during the decay of radon and its progeny cause ionization, The amount of Radon that escapes depends on the amount of ^{222}Rn in the ground, the type of ground cover, porosity and temperature of soil [3]. The air ions are naturally produced due to radioactivity. Natural radioactive ionization is the major source of ions in the atmosphere. Isotopes commonly present in air include ^{7}Be, ^{14}C, ^{22}Na, ^{32}P, ^{33}P, ^{35}S and ^{85}Kr as well as Radon isotopes and their decay products, Gamma radiation, are produced from the soil, also passes through the air. Many naturally occurring elements have radioactive isotopes, but only potassium, and uranium and thorium decay series have radioisotopes producing gamma rays of sufficient energy [4]. Interaction between the energetic radioactive particles and molecules in the air occurs by different processes.

In addition to ionizing radiation, there are several other sources, which produce charge carriers of quite different sizes and nature on a local scale. For example, dust storms and snow storms are known to be intensely electrified [5, 6]. Charges produced in these storms can be transported up to several kilometers in altitude and over many square kilometers of the Earth's surface [7]. Electrical discharges can cause the formation of ions in the atmosphere. This requires high electric field that generally occurs in the disturbed weather inside or in the vicinity of thunderstorms. In such conditions, field intensity is enhanced around grounded elevated objects and when it increases to breakdown value or above, a large number of uni-polar ions are injected into the atmosphere. This phenomenon of point discharge can occur at the tall trees or buildings below thunderstorms. Lightning flashes from thunderclouds also produce local but intense ionization in the atmosphere.

In this paper, air ion variation during morning and evening period is compared at rural station Ramanandnagar. Pollution index is the ratio of positive to negative air ions. By calculating pollution index at two prominent time periods of the day, we try to detect which time period is harmful to the human health.

II. MEASUREMENTS AND METHODS

For the measurement of atmospheric current, various amplifiers are tested. As the atmospheric current is very small, therefore for the measurement of small magnitude of current a separate electrometer is necessary. Commercially available

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instruments exist with resolution of 1 fA, such as the Keithley 6512 [8], but these are bulky and expensive calibration devices unsuited for field work. When measuring such small currents [9], effects often considered negligible in other circumstances are comparable to the signal, such as leakage current, and also 50 Hz interfaces caused by the ac mains supply. Care should be taken to minimize these problems whilst maximizing the time response, by careful design and component selection.

The air ion counter, which is indigenously designed and developed at the Indian Institute of Tropical Meteorology Pune, is being operated at rural station Ramanandnagar [10]. The calibration of the amplifier is done in the laboratory using a resistive method of generating small currents with a milli-volt calibrator and a resistor. To minimize the error due to the turbulence, the ends of inner electrode that face the air stream are curved smoothly.

The flow rate in the Gerdien condenser is given by

$$\Phi = u\,\pi(b^2 - a^2) \tag{1}$$

Where, b is radius of outer cylinder, a is the radius of inner cylinder, u is velocity of air flow.

For fixed bias voltage, the ion current flowing through inner electrode is proportional to the ion concentration. This ion current is measured in critical mobility range 3.37×10^{-4} to 2.02×10^{-4} $m^2/V\cdot s$. Then air ion concentrations can be calculated by using the formula:

$$N = I/e\,\Phi \tag{2}$$

By changing polarity of outer cylinder we can measure positive and negative air ion concentrations. Positive and negative air ions are measured with 30 second time resolution. The air ion concentration collected from January to December 2012 at rural station Ramanandnagar.

III. RESULT AND DISCUSSION

Average air ion variation during morning period (06:00-08:00 hours): During the morning period average positive air ions were $9x10^2$ ions per cm^3, they started decreasing and reaches to minimum ($1.2x10^2$ ions per cm^3) in April as shown in Fig. 1. From May they started increasing and reached $9.1x10^2$ ions per cm^3 in June. In July positive air ions again decreased to $2.8x10^2$ ions per cm^3. Average positive air ions were $7x10^2$ ions per cm^3 in August and $7.2x10^2$ ions per cm^3 in September the number started decreasing and reached minimum ($2.2x10^2$ ions per cm^3) in October. From the October again air ions started increasing and reached maximum (6 $x10^2$ ions per cm^3) in December.

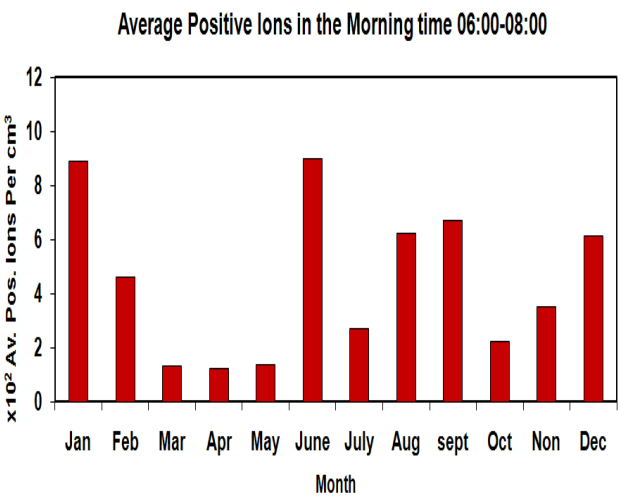

Fig. 1 Average positive air ion variation during morning period (06:00-08:00 hours) at rural station Ramanamdnagar (17° 4' N 74° 25' E) in 2012

In each January, radon concentrations were in peak [11] in which large cluster-ion pairs were produced. This may be due to intense temperature inversions during the colder period (January), leading to the accumulation of more radon near the Earth's surface and increasing the ionization rate [12]. Therefore, as compared to all other months we observed a greater number of positive cluster ions in January during the morning period (06:00-08:00 hours). The radioactive aerosol produced in the presence of radon gas (^{222}Rn), which consists of the radon daughter nuclide ^{218}Po attached to a pre-existing aerosol [13]. Radioactive aerosols acquire a charge, in general, more readily than a comparable non-radioactive aerosol. Radioactive aerosols are charged by the usual mechanism of external ion attachment [14], but additional external ions are created by radioactive decay particles. A further form of electrification for radioactive aerosols is self-charging. This occurs when a radioactive source is actually within the aerosol particle. The self-charging of a beta-active aerosol radioactive decay causes electrons to be emitted from the particle's surface and ions for both signs are produced. Positive ions are nothing but these radioactive aerosols [15], which are accumulated near the ground surface in cold temperatures (January). From January to

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April as temperature increased radon, this is close to surface, escaped to upper atmosphere. Therefore average positive air ions were decreased from January to April. In May more aerosols were introduced in the atmosphere and positive air ions consumed by aerosols in the atmosphere. Therefore average positive air ions were lower in May during morning period (06:00-08:00 hours) as shown in Fig. 1.

July is the monsoon period; therefore ground was covered with water in this month. Then emanations of radioactive radon decreased. Therefore average positive air ions decreased in July. In August and September, there was no continues rainfalls like those in July, there is occasional rainfall and sunshine in this month. Therefore average positive air ions were more in August and September as compared to July. From October to December, as temperature decreased radon close to the surface increased. Therefore average positive air ions increased from October and maximum was observed in December.

During the morning period (06:00-08:00 hours) average negative air ions were $6x10^2$ ions per cm^3 in January as shown in Fig. 2. In February average negative air ions were $5.85x10^2$ ions per cm^3. From February they started decreasing and reached minimum ($1.2x10^2$ ions per cm^3) in April. In June average negative air ions were $9.4x10^2$ ions per cm^3. Average negative air ions were $3x10^2$ ions per cm^3 in July. From July average negative air ions started increasing and reached maximum ($8.2x10^2$ ions per cm^3) in September. In October average negative air ions were $6.3x10^2$ ions per cm^3. From October, average negative air ions started increasing and reached maximum ($9.2x10^2$ ions per cm^3) in December.

As January is a dry month with no rainfall activity, negative ions which are produced immediately attach to aerosol particles. Therefore as compared to average positive air ions average negative air ions were low in January during the morning period. The pre-monsoon period is much-polluted and dusty, which results in more negative ions attached to aerosol particles [16]. Therefore, as shown in Fig. 2, the average negative ion decreased from March to May 2012 during the morning period (06:00-08:00 hours). In the month of June, few thunderstorms were observed, which generated a corona discharge of negative air ions from trees [17]. This additional source of negative ions results greatly increased the concentration of negative ions [18, 19]. Therefore, in June the average negative ion count (Fig. 2) shows sharp growth [20] as compared to May during the morning period.

During summer, the gases move upward carrying radon with it, thereby reducing ionization near the Earth's surface. Therefore, average (Fig. 2) negative ions decreases, from February to April. May is a very hot month of the year, so agricultural crops are few; hence plant transpiration [21] of radon and thoron is the lowest. Therefore, average negative air shows the lowest values in May. The main cause of reduction of the ion concentration is increasing aerosol [22], which removes ions, due to the aerosol acquiring charge. From this, it can be seen that increasing the aerosol concentration reduces negative air ion concentration. Many observations have been carried out in atmospheric air research since polluted or fog-laden air is known to have a lower ion concentration than clean mountain air [23]. Therefore, as shown in the Fig. 2, the average negative air ion concentrations are decreasing from January to May during morning period.

Air ion variation during evening period (18:00-20:00 hours): During the evening period (18:00-20:00 hours) average positive air ions were $11x10^2$ ions per cm^3 in January, which started decreasing and reached to minimum ($1.8x10^2$ ions per cm^3) in April. From May they started increasing and reached $9.9x10^2$ ions per cm^3 in June. In July positive air ions again decreased to 1.9 $x10^2$ ions per cm^3. Average positive air ions were 8.4 $x10^2$ ions per cm^3 in August then they started decreasing and reached minimum (4.2 $x10^2$ ions per cm^3) in October during evening period (18:00-20:00 hours). From the October again they started increasing and reached maximum ($7.6x10^2$ ions per cm^3) in December during evening period (Fig. 3).

From January to April as temperature increased radon which is close to surface escaped to upper atmosphere. Therefore average positive air ions decreased from January to April. In May more aerosols were introduced in the atmosphere, therefore average positive air ions were more in May during the evening period (Fig. 3). Positive ions can be produced by various kinds of friction between air masses, between the air and sand or dirt particles swept up by the wind, between weather fronts that march endlessly across the face of the globe. Friction tends to knock off the negative ions and produce overdose of positive ions. On a dusty or humid day this overdose may be massive because the negative ions [24] promptly attach themselves to particles of dust, pollution or moisture and lose their charge (Pawar et al., 2012). June is transition period between pre-monsoon and monsoon in India, therefore in dusty atmosphere average positive air ions were more.

July is monsoon period; therefore ground was covered with water in this month. Then emanations of radioactive radon decreased. Therefore average positive air ions were decreased in July. In August there was no continues rainfall like in July, there is occasional rainfall and sunshine in this month. Therefore average positive air ions were more in August as compared to July during the evening period. From October to December as temperature decreased radon close to the surface increased. Therefore average positive air ions increased from October and maximum was observed in December during the evening period.

During the evening period (18:00-20:00 hours) average negative air ions were $6.15x10^2$ ions per cm^3 in January (Fig. 4). In February average negative air ions were $4.85x10^2$ ions per cm^3. From February they started decreasing and reached minimum ($0.7x10^2$ ions per cm^3) in May. In June average negative air ions were $9.75x10^2$ ions per cm^3. Average negative air ions were $3.2x10^2$ ions per cm^3 in July. From July average negative air ions started increasing and reached maximum ($10x10^2$ ions per

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cm^3) in October. From October average negative air ions started decreasing and reached minimum (9 $x10^2$ ions per cm^3) in December during the evening period (Fig. 4).

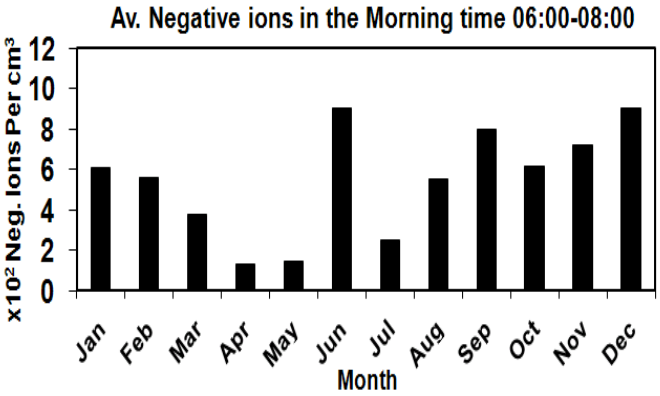

Fig. 2 Average negative air ion variation during morning period (06:00-08:00 hours) at rural station Ramanamdnagar (17° 4' N 74° 25' E) in 2012

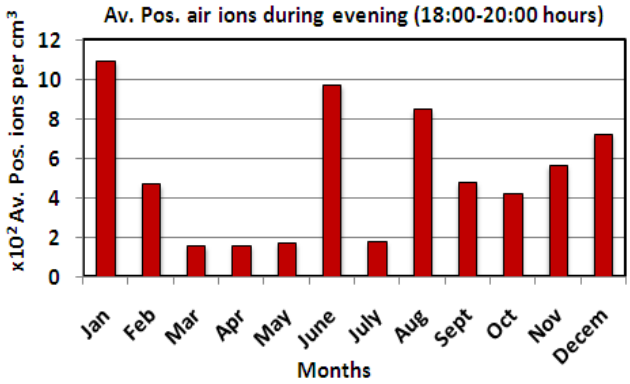

Fig. 3 Average positive air ion variation during evening period (18:00-20:00 hours) at rural station Ramanamdnagar (17° 4' N 74° 25' E) in 2012

The air ion concentration and aerosol concentration are generally considered to have an inverse relationship in the atmosphere. Highly mobile air ions are produced in the atmosphere by cosmic rays and radioactive sources [25]. A balance is maintained since the air ions are being removed from the atmosphere at the same rate they are being produced. They are removed by recombination with oppositely charged air ions and by attachment to aerosol particles. These recombination and attachment process determines the life time of air ions in the atmosphere. During the morning period less number of air ions is attached to aerosol particles. Therefore positive air ions are lower during morning period as compared to evening period. Convective currents in the morning carry aerosol particles up from ground surface and the air ion concretion starts decreasing as sun rises [26]. As day advances the aerosol concentration increases due to anthropogenic activities and air ion concentration decreases. Positive air ions are nothing but aerosols in the atmosphere. Therefore as compared to morning period positive air ions are more during evening period. Highly mobile negative air ions are attached to aerosols particles in the atmosphere. Therefore negative air ions are lower during evening period as compared to morning period.

Comparison of Pollution Index variation during morning (06:00-08:00) and evening period (18:00-20:00 hours): In January more radon close to the Earth's surface and therefore more air ions both the polarities. The self-charging of a beta-active aerosol radioactive decay causes electrons to be emitted from the particle's surface and ions for both signs are produced. Positive ions are nothing but radioactive aerosols, which are accumulated near the ground surface in cold temperatures (January). At the same time mobility of negative air ions is high as compared to positive air ions. Therefore more negative air ions are consumed by aerosols in the morning period. Due to these reasons pollution index is 1.45 in January (Fig. 5). July and August is monsoon season at the measuring site. In this month ground is covered by water, therefore natural air ion production from the ground surface reduced. Highly mobile negative air ions produced from the other sources are consumed by aerosol particles in the atmosphere. Therefore pollution index was 1.1 in July and 1.05 in August. Pollution index above 1.2 is harmful to human health [27]. Therefore atmosphere in the month January was very harmful to human health [28] during the morning period. In all other remaining months' pollution index was below one during the morning period, which is very healthy for human health.

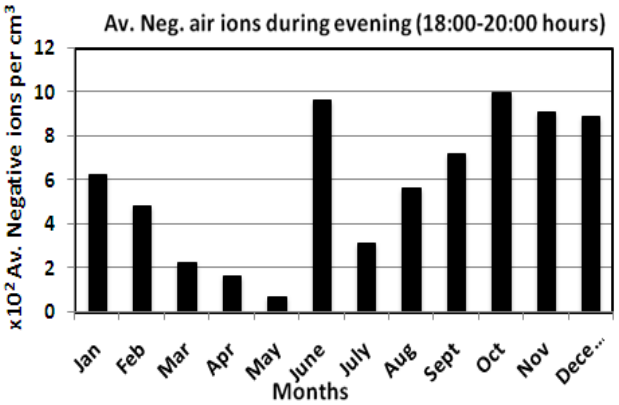

Fig. 4 Average negative air ion variation during evening period (18:00-20:00 hours) at rural station Ramanamdnagar (17° 4' N 74° 25' E) in 2012

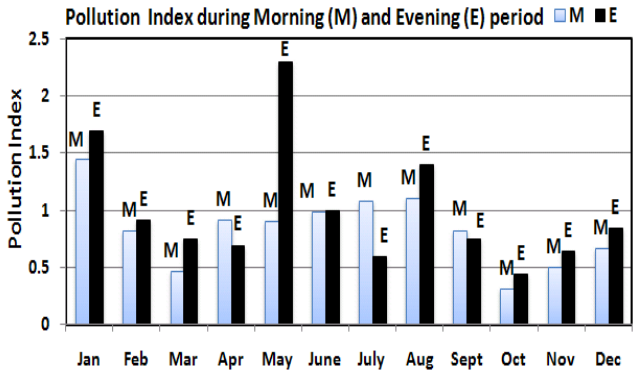

Fig. 5 Comparison of pollution index variation during morning (06:00-08:00) and evening period (18:00-20:00 hours) at rural station Ramanandnagar (17° 4' N 74° 25' E) in 2012

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Pollution index was 1.7 in January during the evening period (Fig. 5). In May the temperature is very high, therefore radon close to the surface escaped to upper layers of the atmosphere. At the same time there are limited sources for the production of air ions [29]. There were no rainfalls in the month of May. Therefore more aerosols were present in the atmosphere. Negative air ions produced from various sources consumed by the aerosols in the atmosphere [30]. There may exist very low negative air ion count in the atmosphere in the month of May. From morning all activities were started. Therefore an aerosol produced from various processes starts increasing and reaches peak in the evening (18:00-20:00 hours) period. Therefore as compared to negative air ions, positive air ions were more during the evening (18:00-20:00 hours) period. Due to this reason as compared to all other months, the pollution index is very high (2.3) in May (Fig. 5), which is very harmful to human health. August is monsoon season at the measuring site. In this month ground is covered by water, therefore natural air ion production from the ground surface reduced. Highly mobile negative air ions produced from the other sources are consumed by aerosol particles in the atmosphere. Therefore pollution index was 1.35 in August. Pollution index above 1.2 is harmful to human health. Therefore atmosphere in the month January, May and August are very harmful to human health during the evening period. In all other remaining months' pollution index was below one during the evening period, which is very healthy for human health.

People going for walking during morning period consume more healthy air ions from the atmosphere except in January. People going for walking during evening period consume more harmful air ions from the atmosphere except in January, May and August. Research in the medicine shows that to ensure good quality of human's life, it is necessary to ensure presence of both negative and positive ions [31]. Increased negative air ion levels are reported to have beneficial effect, but positive air ions are not so beneficial. The negative charged oxygen ions can assimilate organism more easily and thus play very important role in metabolism [32]. Therefore as compared to evening period morning period is very healthy for human health.

IV. CONCLUSIONS

In January average positive air ions were 9 $x10^2$ ions per cm^3, which started decreasing and reached minimum ($1.2x10^2$ ions per cm^3) at rural station Ramanandnagar in April 2012. From May they started increasing and reached $9.1x10^2$ ions per cm^3 in June during the morning period. Average negative air ions were $6x10^2$ ions per cm^3 in January. In February average negative air ions were $5.85x10^2$ ions per cm^3. From February the figure started decreasing and reached minimum ($1.2x10^2$ ions per cm^3) in April during the morning period. As January is a dry month with no rainfall activity, negative ions which, are produced immediately attach to aerosol particles. Therefore as compared to average positive air ions average negative air ions were low in January during the morning period. The pre-monsoon period is a much-polluted and dusty resulting in more negative ions attached to aerosol particles. Therefore, the average negative ions decreased from March to April 2012. In the month of January, pollution index was 1.45 during morning period. Pollution index above 1.2 is harmful to human health. Therefore atmosphere in the January month is very harmful to human health during the morning period. In all other remaining months' pollution index was below 1.1 during the morning period, which is very healthy for human health. Air pollution during evening period can affect human health in several ways. Some of the primary effects of air pollutants include toxic poisoning, causing cancer, birth defects, eye irritation and irritations of the respiratory system, viral infections. Therefore atmosphere in the month January, May and August are very harmful to human health during the evening period.

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