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# Air Ion Variation at Poultry-farm, Coastal, Mountain, Rural and Urban Sites in India

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## ABSTRACT

The air ions are continuously generated and destroyed by various processes in the atmosphere. Near the surface, the nature of ions is very complex and they show large variations in their physical properties. The attachment of small ions to the aerosol particles is depending on the mobility of air ions. High mobility air ions immediately are attached to the aerosol particles and settle down on the surface. In this study we report, about the air ion variation at different sites like Rural, Coastal, Mountain, Poultry farm and urban in the state of Maharashtra in India. The aim of this study is to understand the plausible distribution of air ions both diurnally and at different times in a day for long time (three years) and with various meteorological variables. The preliminary analysis of the data has reveled that negative air ions are observed to have attached to the aerosol particles and large aerosol particles are formed from small aerosol particles. Therefore uni-polarity factor observed to be below unity for coastal, mountain and rural site and about 2.8 at an urban site. However worst case is observed at the Poultry farm, where uni-polarity factor is 6.3, which is very harmful for human health. There is also effect of meteorological parameters on air ion concentration in the atmosphere.

***Keywords:*** Pollution index; Aerosol; Air ion; Transpiration; Meteorological Parameters.

## INTRODUCTION

The air ions are continuously generated and destroyed by various processes in the atmosphere. Near the surface, the nature of ions is very complex and they show large variations in their physical properties. Several factors such as the vertical stability of the lower atmosphere, turbulent wind speed, pollution, radioactivity of plant transpiration and ground influence affect their distribution in the atmosphere (Guedalia *et al*., 1970; Pawar *et al*., 2010). In the atmosphere, Radon appears mostly in the vicinity of its source, i.e., ground, and its transport is determined by thermal processes. When exhaling in the indoor space, Radon is prone to accumulation. Radon entrance and accumulation in residence and offices is related to many local and time dependent factors such as uranium content of the underlying soil, construction material, permeability and number of cracks in the basement shell, ventilation conditions, radioactivity in the air outdoors (Janssen, 2003; Abbady *et al*., 2004) and meteorological parameters (Kitto, 2005). Indoor sources of Radon are soil or rocks under or surrounding the building, construction materials, water supplies, natural gas, etc.

The lightning during thunderstorm injects additional air ions in the atmosphere (Ruhnke, 1969; Roble and Tzur, 1986; Fishman *et al*., 1994; Milikh and Valdivia, 1999; Rodger, 1999). There are several man made sources of ionization such as the exhaust from automobiles or aircrafts and industrial processes (Kamra, 1991, Pawar *et al.,* 2011, Hsieh *et al.,* 2011). Contributions of such local sources to the ion concentration of the atmosphere may be dominant in the neighborhood of such activities. The air ions are ultimately further generated through lightning from thunder cloud, corona discharge, combustion, waterfall, waves on water, splashing of rain drops and due to friction between two air levels depending on the nature of the ecosystems and local atmosphere (Israël, 1970). Kim *et al.* (2010) have presented a numerical model of corona plasma region having a certain thickness was developed to solve the electric field and charge density distributions in a negative wire-to-duct corona discharge in air.

Ion-induced nucleation (Eisele *et al*., 2006) the growth of aerosol particles (Hirsikko *et al*., 2005) by vapor condensing onto an ion, has been shown to be theoretically possible by Castleman (1982). Slower ionic growth has also been reported in Estonia, and it has been suggested that this is the first stage of nucleation process (Hõrrak *et al*., 1998a). In ion-induced nucleation the Coulomb force decreases the energy needed for critical cluster formation (Laakso *et al*.,

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2004) Particles formed via ion-induced nucleation are always charged due to their origin (Hirsikko *et al*., 2011).

The attachment of small ions to the aerosol particles (Hoppel, 1985; Hoppel and Frick, 1986; Hõrrak, *et al*., 1998b) is dependent on the mobility of air ions. High mobility (Hõrrak, *et al*., 1994, 2000, 2003) air ions are attached to the aerosol particles and settle down on the ground (Grinshpun *et al*., 2005; Salm and Tamm, 2011). Therefore, in the regions such as urban place, Pune where the concentrations of aerosols are high and associated air ions become low (Dhanorkar and Kamra, 1993). At a clean atmosphere place like Himalayas, the concentrations of aerosol particles are low and as a result the concentrations of air ions are high (Herve *et al*., 2008). The charge on radioactive aerosols seems universally positive (Dua *et al*., 1978) is probably due to the large number of secondary electrons produced. If the particles knocked out of the aerosol are electrons, then charge remaining on the aerosol particle will be positive. Therefore pollution index or uni-polarity factor is defined as the ratio of positive to negative air ions. The uni-polarity factor nearly one meaning that air is almost aerosol free (Kolarz *et al*., 2009).

In this study the ion concentrations are measured over a verity of ecosystems which helps us to understand the plausible mechanism by which the ions generate and inject in to the earths atmospheric boundary layer. By calculating pollution index, we also try to highlights different sites, which are harmful for human health. Another aim of this study is to see the effect meteorological parameters on air ion variation at rural station Ramanandnagar.

## MEASUREMENTS AND METHODS

The five different sites selected for air ion measurements are the poultry farm site at Palus (17°4'N, 74°28'E) and the mountain site at Sagreshware (17°2'N, 74°E), which are close to rural site Ramanandnagar (17°4'N, 74°25'E) shown in Fig. 1. In addition an urban site at Pune (18°32'N, 73°51'E) and a Coastal site at Ganapatipule (17°N, 73°19'E) are chosen for comparison. The area around Ganapatipule is covered with trees like mango, betelbut, banana, jackfruit, coconut, etc. The climate is moist and humid but healthy and devoid of pollution Fig. 2(b).

The area around observatory at Pune is an open ground with some patches of grass on the black cotton soil. There is major urban activity to the east of the observational site. Particulate matter and air ions in urban area originate from exhaust of automobiles or aircrafts, industrial processes. At Tropical place like Pune climate is marked by highly convective conditions, dusty atmosphere, high frequencies of calm conditions and reduced wind. At rural station Ramanandnagar Fig. 2(a), climate is marked by clean atmosphere, very less dust particles in the air, low frequencies of calm conditions and high wind speed. Moreover, unlike in mid-latitudes, the ground is not covered by snow in the winter at rural station Ramanandnagar. Under such conditions, therefore, properties and distribution of ions in the atmosphere are expected to be different than that at Tropical place like Pune and mid-latitudes like Estonia.

The poultry farm grows Beb-Cock in 3 sheds of 23 meter long each containing 2000 birds, which are shown in

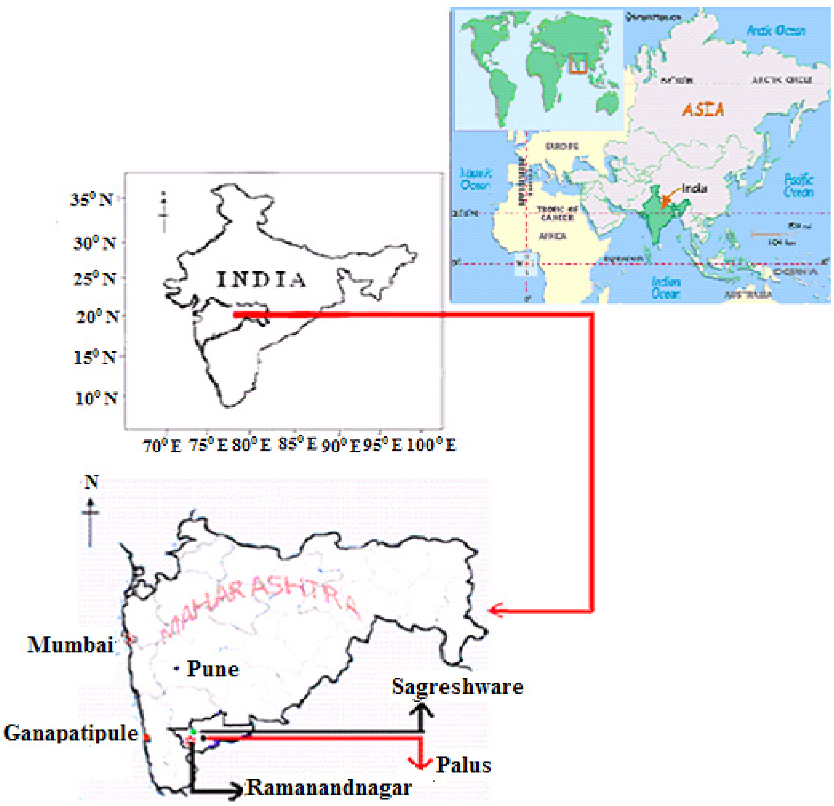


**Fig. 1.** Different air ion monitoring stations in India.

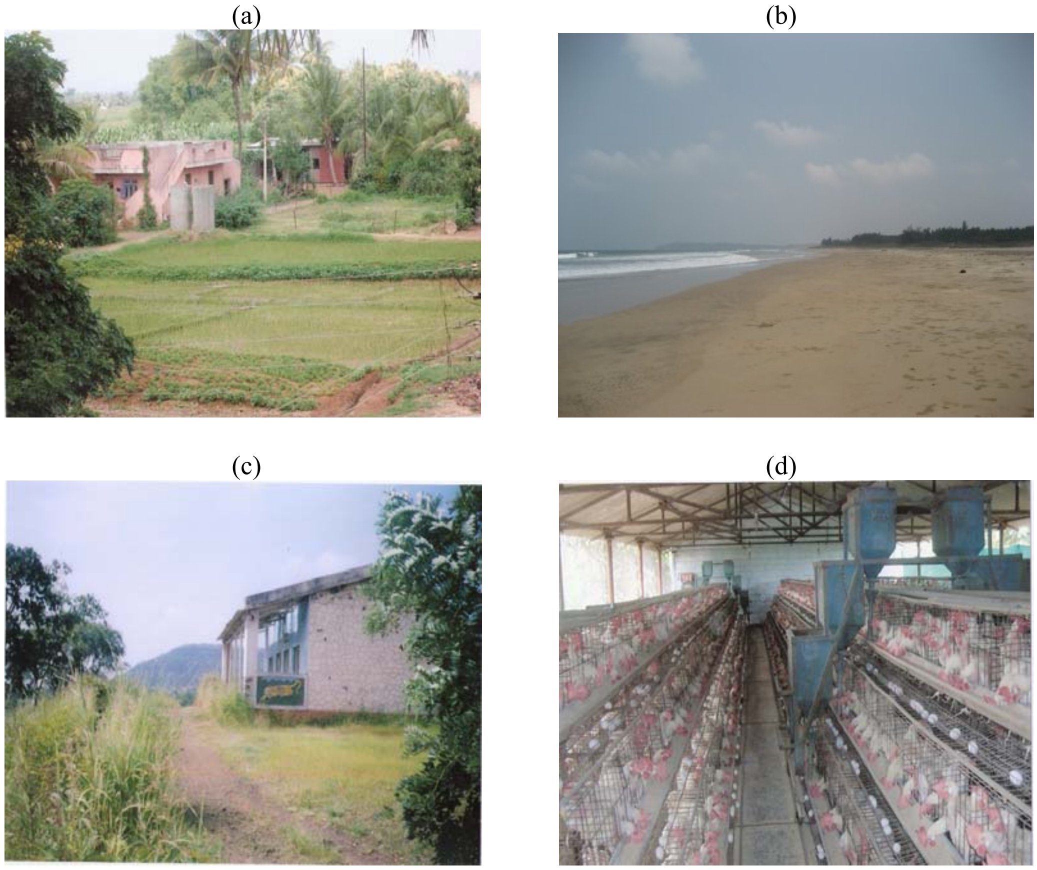


**Fig. 2.** (a) The vegetated area infront of the observatory at rural site Ramanandnagar, (b) Coastal site Ganapatipule, (c) Mountain Site Sagreshware, (d) Poulltry farm site at Palus .

Fig. 2(d). The modern poultry system contains large variety of pollutants, such as volatile organic compounds, gases like ammonia, and carbon dioxide, dust micro-organisms and end toxins. These aerosols also referred to as bio-aerosols. Animal respiratory health may be compromised by these (Hartung, 1994) pollutants. The Mountain site Sagareshwar is man made forest without perennial supply of water shown in Fig. 2(c). At the Sagreshware cosmic-ray at the same time Radon and Thoron emanations from the ground and from the Plant transpiration are the main sources of air ion production.

The air ion counter, which is indigenously designed and developed at the Indian Institute of Tropical Meteorology Pune, is being operated at different atmospheric conditions (Pawar *et al*., 2010). 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. There is only one set of instrument for the measurement of air ions. Therefore to study the air ion variation at mountain, urban, coastal and poultry farm readings are recorded occasionally.

The flow rate

$$\Phi = u\,\pi(b^2 - a^2) \quad (1)$$

where, b-is radius of outer cylinder, a-is 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·s. Then air ion concentrations can be calculated by using formula

$$N = I/e\,\Phi \quad (2)$$

where, I-is input current, Φ-is flow rate, e- is the charge of air ion.

Note that it is not possible to measure positive and negative ion concentration simultaneously at a time. Therefore, we have measured the air ions of particular kind that is positive or negative ion on alternate days or epochs according to our convenience. By changing polarity of outer cylinder we can measure positive and negative air ion concentrations. Positive and negative air ions are measured for 796 days with 30 second time resolution for different atmospheric sites are shown in Table 1.

## RESULT AND DISCUSSION

### *Air Ion Variation at Different Atmospheric Stations*

Fig. 3(b) shows the magnitude of negative ion count varies from 6–12 × $10^2$ ions/$cm^3$ at mountain site, which is a very large compared to all other site. Whereas the magnitude of

**Table 1.** Positive and negative air ion measurements with 30 second time resolution for different atmospheric conditions.

| Sr. No | Name of site | Period | Positive and negative air ion measurement with 30 Sec. time resolution in no. of days |
|---|---|---|---|
| 1 | Rural site Ramanandnagar (17°4'N, 74°28'E) | 01/06/2007–30/12/2009 | 336 |
| 2 | Urban site Pune (18°32'N, 73°51'E) | 01/06/2007–30/12/2009 | 126 |
| 3 | Poultry farm site Palus (17°4'N, 74°28'E) | 01/06/2007–30/12/2009 | 126 |
| 4 | Mountain site Sagreshware (17°2', N74°E) | 01/06/2007–30/12/2009 | 168 |
| 5 | Coastal site Pune (17°N, 73°19'E) | 01/06/2007–30/12/2009 | 40 |

positive ion counts, which are shown in Fig. 3(a), varies from 6–8 × $10^2$ ions/cm$^3$, is observed smaller than the observed at urban site. This indicates that at mountain site pollution is very small as compared to all other sites. Reduction of the ion concentration when aerosols are added to the system shows that the aerosol is indeed removing ions. From this it can be seen that increasing the aerosol concentration reduces the air ion concentration, a result which is backed by many observations in atmospheric air since polluted or fog laden air is known to have a lower small ion concentration, than clean mountain air, (Reiter, 1986). At the Sagreshware cosmic-ray at the same time Radon and Thoron emanations from the ground and from the plant transpiration are the main sources of air ion production. As there are very few sources of aerosols therefore more negative ions are present at mountain site.

At coastal site positive air ions are changing from 0.5 to 2 × $10^2$ ions/cm$^3$ (Fig. 3(a)), while negative air ions are changing from 2 to 5 × $10^2$ ions/cm$^3$ (Fig. 3(b)). The production of "small ions" (Molecular cluster ions) occurs throughout the atmosphere. Away from the continental boundary layer, cosmic rays are the dominant source of small ion production but near the surface, ion production is enhanced by vertical transport of radon isotope and gamma sources in the soil. Continental air has larger aerosol concentrations and larger ion production rates, whereas cleaner marine air is exposed to fewer ion production sources, largely cosmic radiation and a small contribution from breaking waves. Air ions lifetime in air is determined by the local aerosol removal by attachment, whereas in clean air the removal occurs primarily through self-recombination (Harrison and Carslaw, 2003). Therefore negative ion count is high as compared to positive ion count at coastal site.

Magnitude of both positive and negative ion count is found to be low at coastal site and higher at mountain site. Positive ion count is higher at urban station Pune and negative ion count is higher at rural and mountain sites. Variation of positive air ion concentrations in July 2009 at urban site Pune is higher during the night time than that of during day time and with maxima in the morning (Nagaraja *et al.*, 2003). Similar types of observations are noted by Wait and Torreson (1935), Norinder and Siksna (1953). This morning maximum can be seen to be the combined effect of the two processes. First, the production of small positive ions and aerosol particles increases during the night time due to accumulation of radioactive emanations, trace gasses and aerosol particles below inversions. Afterwards, an increase in diffusivity caused due to enhanced solar radiation after sunrise tends to reduce the concentration of radioactive emanations and aerosol particles close to ground. As the observation site is surrounded by hills, therefore accumulation of radioactive emanations and aerosols trapped below inversions on the slopes of surrounding hills during the night time and their advection by mountain winds in the morning down, the slopes of the measuring site in the valley, may contribute to such large concentrations of ions (Dhonarkar and Kamra, 1991, 1992). Increase in the solar, radiation after sunrise causes increase in the turbulent mixing and consequently the nuclei concentration close to the surface decreases (Law, 1963). This results in a decrease in positive air ion concentration approximately 3–4 hours after sunrise. The highly mobile negative ions which are formed due to ionization, soon attach themselves to the larger aerosol particles. Therefore, it is observed that as compared to clean mountain site, magnitude of negative air ions is very low at Pune. Zhu *et al.* (2010) have studied pollution concentration in both indoor and outdoor environments in China. High concentrations of pollution species were observed during winter. Misaki *et al.* (1972) measured the dynamic spectra of atmospheric ions at two locations having different pollution levels and observed very high concentrations of small negative ions throughout the day in clean air. However, in polluted air such ion concentrations were observed only during the night. In tropics, climate is marked by highly convective conditions, dusty atmosphere, high frequencies of calm conditions and reduced wind shear due to smaller Coriolis Effect. This is the main cause behind the reduction of negative ions.

At the rural site negative air ion count changes from 2–5 × $10^2$ ions/cm$^3$ (Fig. 3(b)), while positive air ion count changes from 1.5–4 × $10^2$ ions/cm$^3$ (Fig. 3(a)). Air ion count curve of both polarities increases from early morning and reaches to maximum at noon time rather than night (Israël, 1965, 1969). At the rural site Ramanandnagar the area is surrounded by crops like sugarcane; corn etc. Therefore, plant transpiration comes in the picture (Guedalia *et al.*, 1970). Plant transpiration produces Radon and Thoron gas, which in turn produce ion pair production (Allen *et al.*, 1964). On a dusty or humid day there is overdose of aerosols may be massive because the negative ions promptly attach themselves to particles of dust, pollution or moisture and lose their charge (Gabby, 1990). Therefore, magnitudes of negative air ions are very large in mountain site, medium at sea-shore site and lowest at the urban site Pune.

### *Average Air Ion Variation at Mountain Site and Coastal Site*

Here Average air ions are defined as average value of air

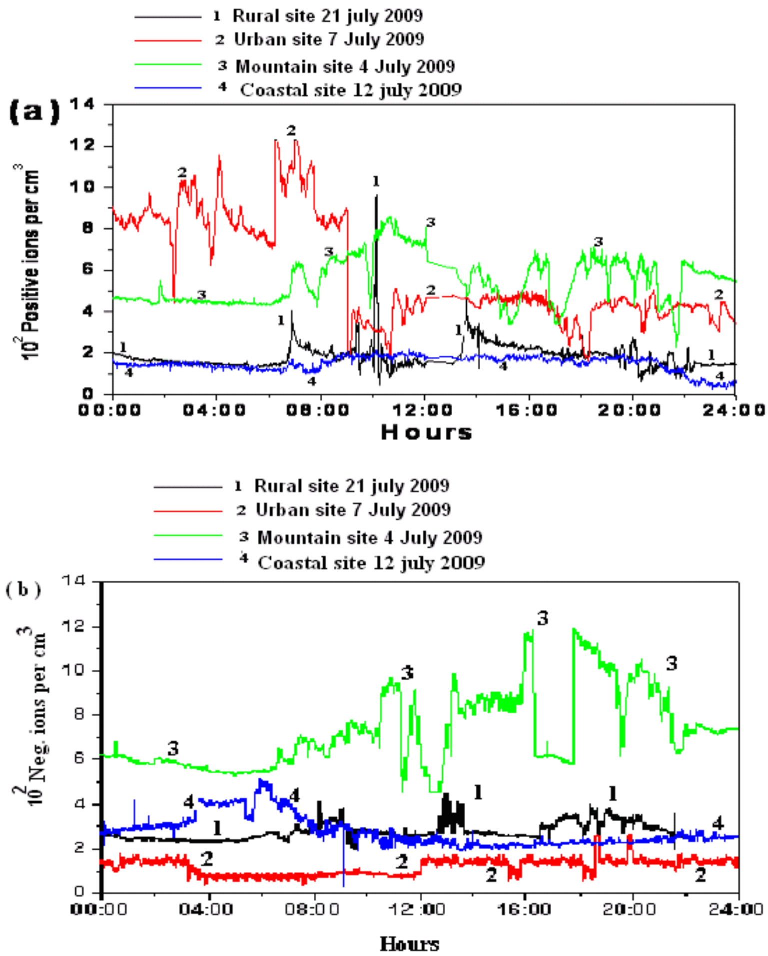


**Fig. 3.** Diurnal variations of (a) Positive and (b) Negative air ions at different atmospheric stations.

ions for time resolution of 30 second for 796 days at different atmospheric sites as shown in Table 1. Fig. 4(a) shows an average positive ions changing from 4–5 × $10^2$ ions/cm$^3$ at the mountain site, while average negative ions are changing from 6–7 × $10^2$ ions/cm$^3$, which are shown in Fig. 4(b). At the sea-shore site average positive ions changing from 1–2 × $10^2$ ions/cm$^3$ Fig. 4(c), while average negative ions are changing in the range from 2–4 × $10^2$ ions/cm$^3$ Fig. 4(d). Due to additional source of plant transpiration of radon at mountain both positive and negative ions are higher. At sea-shore site only cosmic ray is major source for ion production (Markson, 1981). Therefore, both average positive and negative ions are lower at coastal site. Due to clean atmosphere, less number of negative ions is consumed by the aerosols at Ganapatipule and Sagreshware. Therefore as compared to average positive ions average negative ions are more at both the site. An average positive ion at Ganapatipule increases from 06:00 hours and peak is observed between 12:00 and 14:00 hours, while negative ions increases during 06:00–08:00 hours and dip is observed during 12:00–14:00 hours. More aerosols are introduced during 12:00–14:00 hours; therefore more negative ions are consumed by aerosols. Due to this reason, average positive ion peak and average negative ion dip was observed during 12:00–14:00 hours (Figs. 4(c) and d).

### *Air Ion Variation at Poultry Farm Site*

Negative ion count varies below 4 × $10^2$ ions/cm$^3$ and positive ion count varies below 14 × $10^2$ ions/cm$^3$, large variations are observed in positive are ion variation Fig. 5. Inside the poultry-farm average positive ion maxima of 11.64 × $10^2$ ions/cm$^3$ is observed during the period 06:00–08:00 hours, while average negative ion maxima of 1.59 × $10^2$ ions/cm$^3$ observed during the period 12:00–1400 hours, which are shown in Fig. 6(b). Average positive ion minima of 1.35 is observed during the period 12:00–14:00 hours (Fig. 6(a)) and negative ion minima of 0.34 × $10^2$ ions/cm$^3$ is observed during the period 00:00–02:00 hours. Dust generated during the hatch in commercial hatcheries has also been implicated in pathogen cross contamination to other areas of the hatchery such as the exhaust ducts, chick room, egg room, etc (Cason *et al*., 1994; Bailey *et al*., 1996). Negative air ionization has been shown to be effective for reducing viral transmission of newcastle diseases virus between 27 and 100% (Estola *et al*., 1979; Mitchell and King, 1994). This indicates that negative ions inside the poultry are attached to the aerosol particles and larger aerosol particles are produced from the smaller aerosol particles (Gabbay, 1990). Poultry farm is the dustiest site. Therefore negative ion count is very low as compared to positive ions inside the poultry farm.

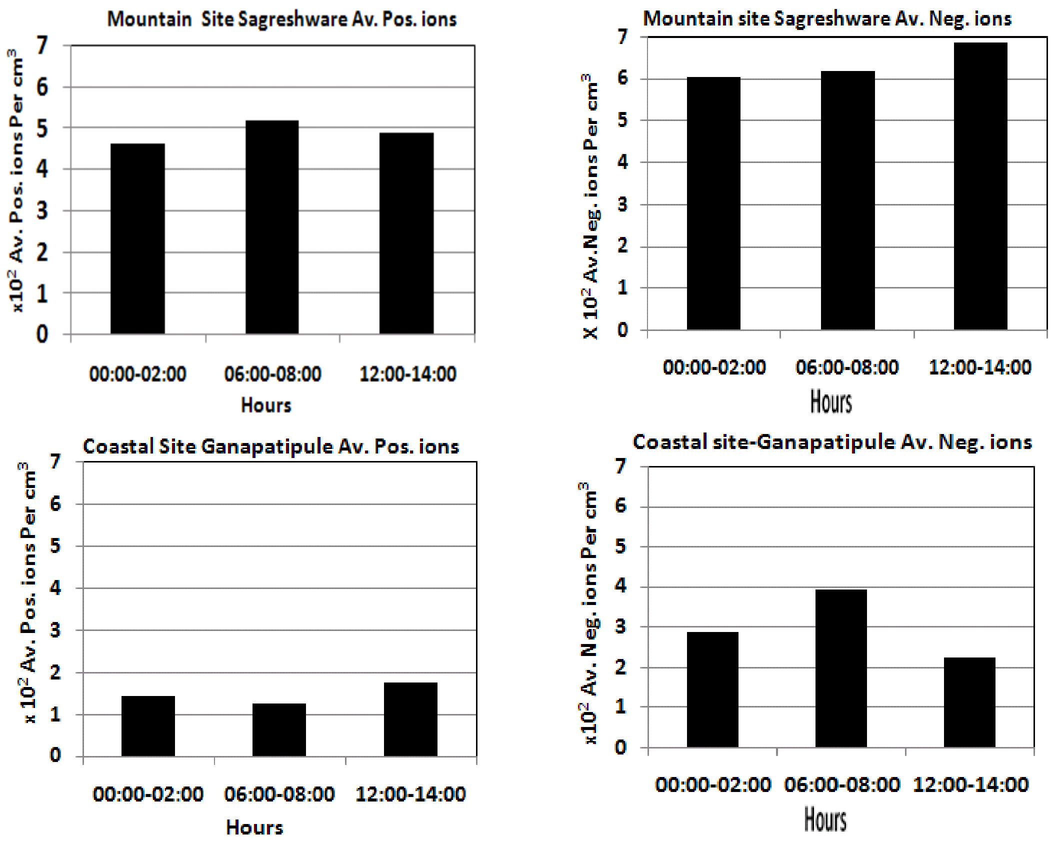


**Fig. 4.** Average Positive and Negative air ion at the Mountain, coastal site.

***Comparison of Pollution Index at Different Atmospheric Conditions* (*2007–2009*)**

The uni polarity factor is the ratio of average positive to negative air ion ratio is below unity for coastal, mountain and rural station. Meaning of this is that all these sites are aerosol free. In the case of urban site average positive to negative ion ratio is 2.8. This is because due to pollution more negative ions are combined with aerosols in the atmosphere (Fig. 7). Worst case is observed at poultry farm site, where uni polarity factor is 6.3. Poultry dust is complex mixture of organic and inorganic material derived from soil bedding, feed and feed comports. As with bacteria, fungi present in poultry dust bio-aerosols may be derived from soil and dust generally present in any agricultural environment and from feed and bedding. The highly mobile negative air ions are consumed by the aerosols and odor present in the poultry and finally settled down on the surface. Positive air ions are nothing but aerosols, bio-aerosols, grains and soft wood are very high, therefore as compared negative air ions magnitude of positive air ions is very high inside the poultry-farm. Then significant differences in poultry farm uni polarity factor (6.3) were caused by high mobility negative air ions are consumed by aerosols and consequently higher rate of neutralization. Such highly polluted atmosphere could trigger allergic respiratory disease and exacerbate existing respiratory allergy. Donham *et al*. (2000) have reported evidence of close related decline in lung function in poultry workers. Uni polarity factor above 1.2 is very harmful to human health (Krueger and Reed, 1976, Takahashi *et al*., 2008). Positive to negative ion ratio is below 1.2 at Coastal, Mountain and Rural station. Due to this reason; these places are very good for human health. Positive to negative ion ratio at urban and Poultry-farm station is above 1.2. Therefore these two places are very harmful to human health. Thus, from the knowledge of uni-polarity factor, we can determine pollution level at different atmospheric conditions.

***Average Monthly Variation of Maximum Positive and Negative Air Ions with Respect to Meteorological Parameters at Ramanandnagar* (*2007–2009*)**

In order to understand the variations of the ion movement and their quantity on monthly basis in relation to some important meteorological variables, the meteorological observations are made along with the ions at a rural station Ramanandnagar for period of three years, which are shown in Figs. 8(a–g). It is interesting to note that both the positive and negative air ions have shown the same trend (in both curves), almost in all months, except in the month of October–November. In the month of October the positive ion curve shows deep dip from September to October, while in November the negative ion curve shows a shallow dip from October to November. This conspicuous change may be occurring due to change in season from South-West monsoon to North-East monsoon due to transition. Nevertheless, the ions count month after month differ between them, which is also quite conspicuous and the positive ion count seems slightly higher than the negative ion count in some months.

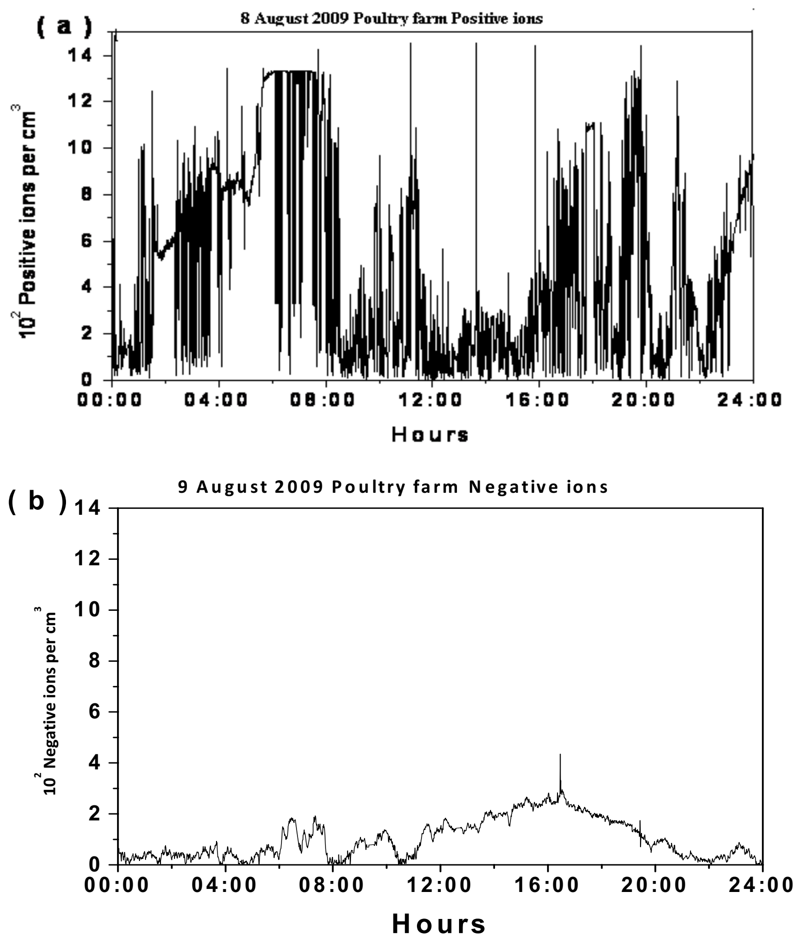


**Fig. 5.** Typical diurnal variation of (a) positive ion concentrations (b) negative ion concentration inside the poultry farm site.

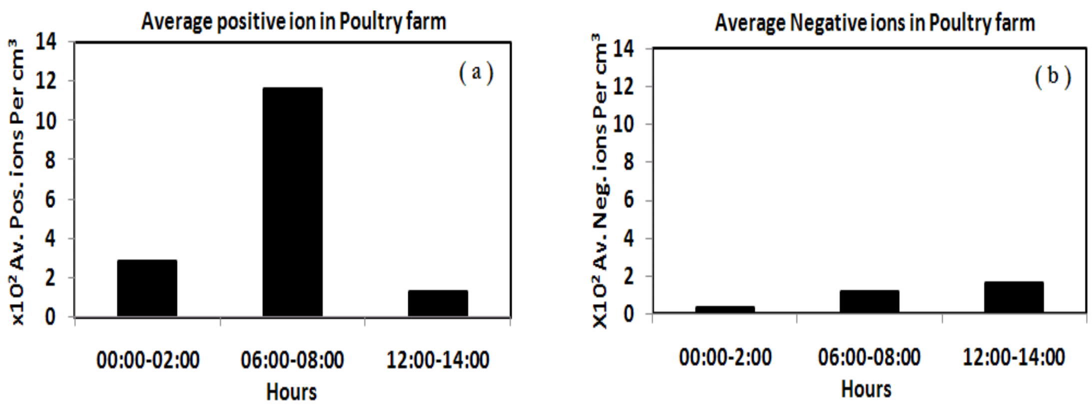


**Fig. 6.** Average Positive and Negative air ion at the poultry farm site.

A close examination and comparison of both the curves of positive and negative ion count with those of the maximum temperature and relative humidity seem to illustrate that the air ion curves tend descend with ascending maximum temperature curves from January to May vary from 11 × $10^2$ ions/cm$^3$ to 1.5 × $10^2$ ions/cm$^3$ of positive ions and 6 × $10^2$ ions/cm$^3$ to 1.2 × $10^2$ ions/cm$^3$ of negative ions with the respective increase of temperature from 30°C (January) to 41°C (May) and relative humidity has decreased from 90 to 65% during the corresponding period. Similarly, during the same period (January to May) the total cloud cover increased from 20 to 50% (but in stepwise tendency) and the rainfall also follow the same trend from 0 to 20 mm.Whereas the wind speed shows a trivial modulation from 2 to 6 m/s (January to May). There is an exorbitant increase in air ions count from May to June from 1.5 × $10^2$ ions/cm$^3$ of ions of both polarities. This exorbitant increasing tendency in the ionic count is followed by step decrease in temperature from 41 to 34°C, an increase in R.H. from 65 to 90%, clouds from 50 to 80%, the rain fall from 20 to 50

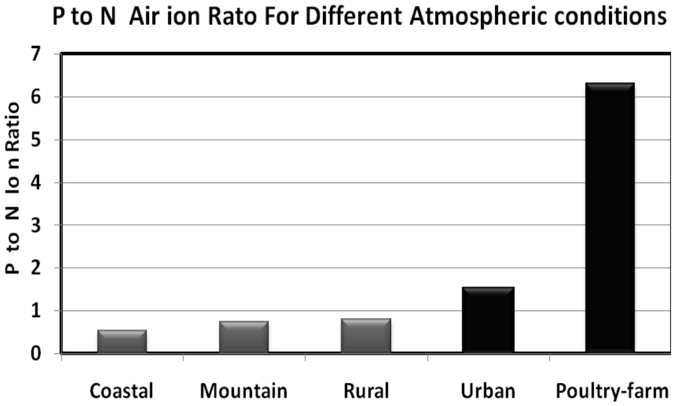


**Fig. 7.** Average Positive to Negative air ion ratio at different atmospheric conditions (2007–2009).

mm and wind speed from 6 to 8 m/s. Indeed in the following month from June to July, the ion count exciting increase has ceased and again rapidly reduced to a value of 2.5 × $10^2$ ions/$cm^3$ in positive ions and 3 × $10^2$ ions/$cm^3$ in negative ions and the corresponding temperature, R.H. and rainfall also show a further fall in their respective value from 34 to 29°C, 90 to 80% and 50 to 22 mm. Whereas the cloud cover and wind speed have remained same as the June value (80% and 8 m/s, respectively).

From July to August the maximum temperature continues to decrease and attain a lowest value of 27°C, the R.H. increases slightly but rain fall tend to decrease (50 to 20 mm) keeping the total cloud cover and wind speed remain the same as July values. Where as the ion count has increased steeply but not like the one which has happened in June. In the month of August both the ions count remain the same value of 7 × $10^2$ ions/$cm^3$, up to the month of August the trend of variation of both ion polarities behaved in same manner, keeping the orientation of the curves same in all respects. But the meteorological variables vary widely month after month depending on the march of the Sun and associated changes in the energy out put from it. Nevertheless this same trend orientation of the curves of both polarities is observed to have deviated from each other and made independent behavior. On the curve of positive ions, the air ion count shows a slight increasing tendency from August to September, a step decrease from September to October and again a gradual increase from October to December. While on the curve of negative ions, the air ion count shows a slow decreasing tendency from August to October, a further sharp decrease from October to November and again a sharp rising tendency from November to December. However, the modulation of the air ion count of both the polarities is seen around value 6.5 × $10^2$ ions/$cm^3$. During the same period from September to December the meteorological parameters shows a typical behavior. The maximum temperature starts rising slowly and attain a value of 32°C from August to October, and gradually decreased from October to December to a value 30°C in December. The R.H. shows slow increase from August to September to 95°C and gradually decreased to a value 85% in December. The total cloud cover showed a knick in October (75%) and rise in November (80%) and step decrease in December to 30%. The rainfall attains a second maximum (45 mm) in September and decreased from September to December (zero rainfall). The wind speed in September is 8 m/s and 3 m/s in October and remained same in November and December.

Sun is the source of energy at the Earth's surface; it has its apparent motion with respect to the earth responsible for the generation of the ions on the earth's surface. India is a tropical country having about 26 states. Among these, the Maharashtra is one of them, in which the Deccan plateau lies with Western Ghats lies on the western side of the state. On the east of the Western Ghats the River Krishana catchment lies and the District Sangli lies in this catchment. The Western slopes of the western catchment are swept by the Arabian Sea coast from Goa to Gujarat. Ramanandnagar site lies in the Krishna catchment in Sangli District. India experiences two famous monsoons known as South-West monsoon and North-East monsoon. The former occur during the summer months from June to August and extend up to September, perhaps to the middle October, which is autumn season. While latter occurs in the months of early autumn that is October and November. India experiences winter conditions during the months from December to February (dry weather) and sprucing conditions from March to May. It is well known that these seasons over India follow the Northward and Southward march of Sun across the earth's equator. Therefore maximum temperatures follow Sun's march and attain a maximum temperature in May to June and minimum temperature in December to January. However, as we have seen in Fig. 8(c), the maximum temperature rises from January to May (highest = 41°C) and then decreases from May to August and again rises briefly from August to October (32°C) and decreases in the following months (November and December). Examination of the rainfall has revealed that it sets in June reaches maximum in July and continues up to September (with less intensity). Although the period June to August is defined as the summer months, the temperatures have declined mainly due to the fact that there are monsoon rains in the area during this period and due to effect of rainfall, temperatures must decrease in accordance with the monsoon wind flow (always from the neighboring Arabian Sea to the main land, South-West winds) Fig. 8(f). According to the distribution of R.

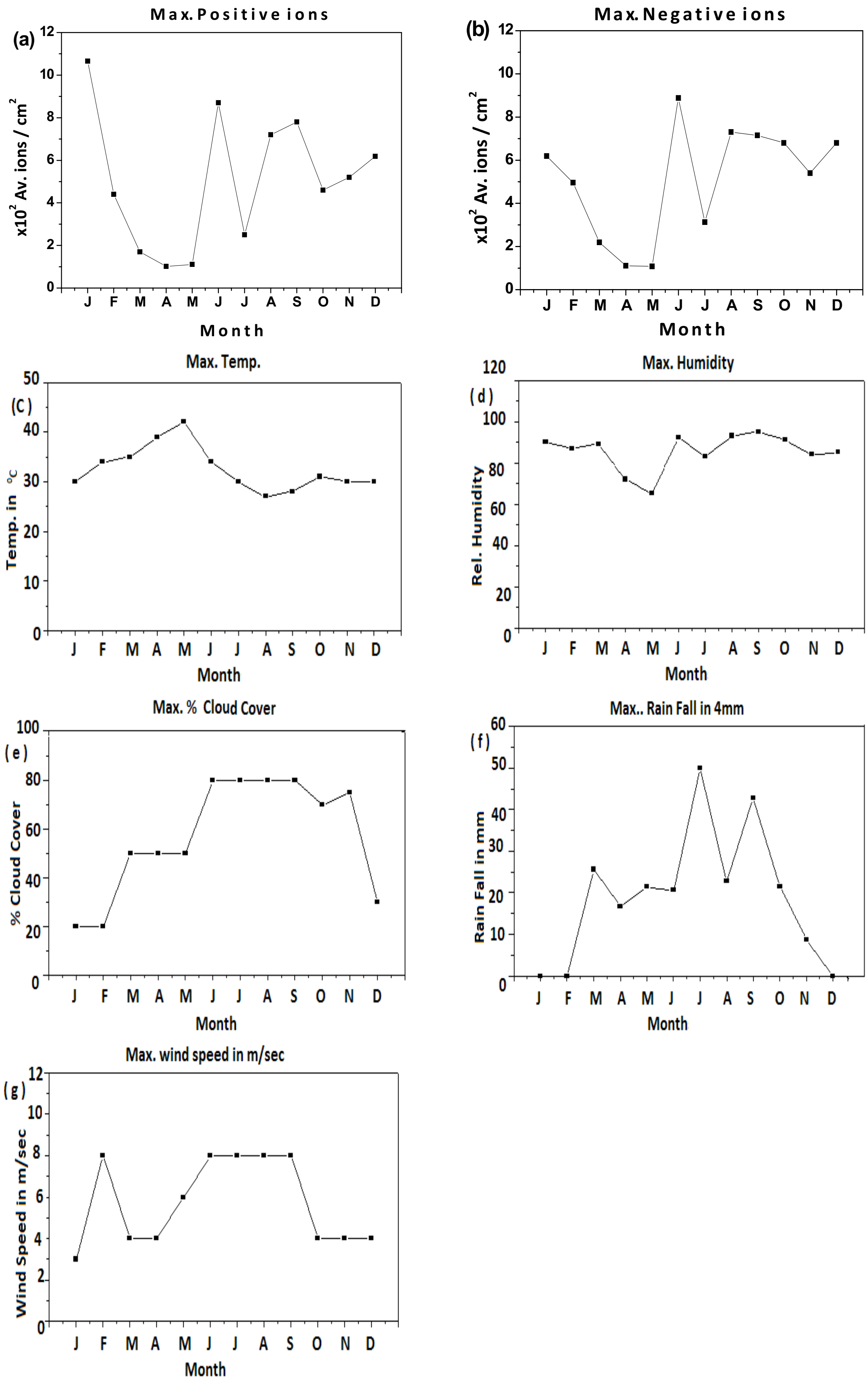


**Fig. 8.** Average monthly variation of maximum (a) positive air ion, (b) negative air ion, (c) temperature, (d) humidity, (e) cloud cover, (f) rain fall, and (g) wind speed , at rural site Ramanandnagar.

H. Fig. 8(d), the driest month is May (65%) and the wettest months from June to September (> 90%). This reflected in the distribution of clouds as shown in Fig. 8(e) with low cloud months during March to May and high cloud months (80%) during June to September and followed to November (with low magnitude). The winds also behaved according the season with minimum wind speed (~4 m/s) from March to May and maximum wind speed (8 m/s ) during June to September (Monsoon winds).

It is well known that according to the ionic theory, molecules of any salt, acid or base being dissolved in water break up into their constituent ions (Shen *et al*. 2011). Similarly in the free atmosphere, the terrestrial ecosystems modulate aerosols (atoms and molecules) the positive radical of molecule of the solution moist air or a comporting of air mass carriers a positive charge and is known as positive ion and negative radical of the molecule carries the negative charge and becomes negative ion. Here we can visualize the rain water as a solution of dissolved air composition. The air ions are ultimately generate through lightning from thunder clouds, corona discharge, plant transpiration, combustion, water falls, wave breaking on water, splashing of raindrops and finally due to friction between two air levels and colliding of two air masses of different density and moisture. In fact the thunders in the atmosphere develop when two dry and wet air mass collide each other. Comparison of the Figs. 8(c) and 8(d) with the Figs. 8(a) and 8(b) one can easily understand that the ions of both the polarities follow the temperature, implying that ion count decreases with increasing temperature and decreasing relative humidity from January to May. The ionic excitement started with the injection of moisture (water vapour) into the atmosphere following the southwest monsoon wind over observed site. This excitement in the ion production has continued during whole period of monsoon (June to September) following the cloud formation and heavy rainfall Figs. 8(e) and 8(f). The ionic stability (more or less remain at constant value of 6–7 × $10^2$ ions/$cm^3$ ) has occurred during the period August, September and October during which period the air hold maximum relative humidity(> 90%) Fig. 8(d). This stability in ionic concentration is seen to be followed by change in the maximum temperature from high value (41°C) to August low value (27°C). During same period the R.H. also oscillated abruptly. From October onwards the weather situation changes considerably and the ionic concentration also changed conspicuously depending on the R.H. (Harrison and Aplin, 2007) and consequent cloud, rainfall and wind speed. The thunder cloud generates an air ion in the atmosphere, the rainfall scavenges the ions and winds carry the ions from one place to the other. So, that the ion concentration, at any rural site like one we observed, is always hampered by the above process in addition to the chemical production and decay of the ions.

## CONCLUSIONS

Negative air ions generated from different sources like lightning, plant transpiration, and radioactivity are consumed by the aerosols present in the atmosphere. While positive air ions are nothing but aerosols. Therefore average negative air ions are more at coastal, rural and mountain site, while average positive ions are more at urban site and poultry farm site. Positive and negative air ions are comparable at rural site and coastal site. In the case of urban site average positive to negative ion ratio is 2.8. Worst case is observed at poultry farm site, where positive to negative ion ratio is 6.3. Negative ions are consumed with odor and aerosols produced in the poultry farm. Therefore pollution index is very high in the poultry farm as compared to all other sites. Positive to negative ion ratio is below 1.2 at Coastal, Mountain and Rural station, due to this reason; these places are very good for human health. Positive to ion ratio at urban and Poultry-farm station is above 1.2, therefore these two places are very harmful to human health. For peak of positive and negative air ion concentration only temperature is not responsible but other meteorological parameters and precursor concentration level also equally important.

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