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WEEK DAY AND WEEK END AIR ION VARIABILITY AT RURAL STATION RAMANANDNAGAR (17° 4′ N, 74° 25′ E), INDIA

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ABSTRACT

Globalization and liberalization polices of the government of India have increased the number of road vehicles nearly 92.6% from 1980-81 to 2003-2004. Therefore to know whether there is effect of increase of industrialization in the urban areas like Pune (18° 32′N, 73° 51′E); Mumbai (18° 55' N, 72° 54' E) and at rural station like Ramanandnagar (17° 4′ N, 74° 25′ E); pollution index is measured. Pollution index which is ratio of average positive to negative small air ion ratio is plotted for week days and week end. At the rural station like Ramanandnagar Monday to Saturday are working days, while Sunday is holiday. It is observed that ratio of average positive to negative small ion ratio is maximum for all time periods during the week day as compared to week end. The data have been collected during the period from first 1 June 2007 to 31 May 2008; the period under analysis involves 8,040 hours shows that the peak of the positive to negative small air ion ratio is observed in winter, and dip is observed in post-monsoon season. As Ramanandnagar is surrounded by vegetation area, therefore due to plant transpiration of Radon and Thoron small air ion maximum are observed at noon time rather than night time. During the week end positive small air ion count is low as compared to week days. While during week end negative small air ion count is very high as compared to week days, which is observed in all the seasons. Post-monsoon is the transition period during which few thunder storms are observed. Due to these thunder storms additional amount negative ion are introduced and positively charged aerosols are cleared from the atmosphere. Therefore in the post-monsoon negative small air ion count is high as compared to all other seasons. Such type of diurnal variation of small air ion detected at rural station Ramanandnagar has never been observed elsewhere.

KEYWORDS: Cluster air ion, Plant transpiration, Aerosol, Positive to negative air ion ratio, Pollution Index.

INTRODUCTION

Atmospheric small ions are small molecular clusters carrying a net electric charge. They are produced by ionization of molecules in the air, and these ions are quickly clustered by water molecules to produce a central, singly charged ion surrounded by 4-10 water molecules. Molecules or molecular complexes of the atmospheric constituents that have lost or gained a negative charge, or electron are termed as air ions. The removal of electron from the particle requires some external energy. Such energy may come from radioactive substances such as radium and thorium. Radioactive gases such as Radon, Thoron, cosmic rays, electric discharges, and frication electricity produced by blowing sand or drifting wave on river water, splashing water from rain showers, Ultraviolet rays, X-rays and combustion processes produce energy. Air ions exist at typical ground level concentrations over land of, on average, a few hundred per cubic centimeter. They are subject to considerable variability from atmospheric turbulence and transport effects. This influences the ion concentration both directly and indirectly via the aerosol population, as identified by Rutherford (1897). Experiments on influence of dust 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 dust in the air was found to very greatly affect the conductivity. Since the dust particles are very large compared to the ions, an ion is more likely to strike against dust-particle, and give up its charge to it or to adhere to surface, than to collide with an ion of opposite sign. In this way, the rate of loss conductivity is rapid. On a smaller scale, the emission of aerosol from vehicles and industry is also pressing issue (e.g. Wehner *et al*., 2004; Flanagan, 1966; Arnold, 2006). Most pollution-related aerosol particles are thought to be harmful to human health because of their number or mass concentration, size or chemical composition (Pope, 2000).

As India is fast developing country, due to globalization and very cheap labor cost in India, industrial plants are increased (Bonasoni *et al*., 2008). During the last two decades, number of registered motor vehicles has increased from 5.4 million in 1980-1981 to 72.7 million in 2003-2004 (Teddy, 2006). During 2004-2005 Indian civil aviation accounted for more than 24% increase in the number of international and domestic flights from 1976-1977 (Teddy, 2007). To know whether there is effect of increase in industrialization in the urban areas like Pune (18° 32′N, 73° 51′E), Mumbai (18° 55' N, 72° 54' E) in India and on rural station Ramanandnagar (17° 4′ N 74° 25′ E) pollution index is measured. The road in front of monitoring station is connected with number of industries, schools, college, banks, at rural station Palus (17° 4' N 74° 28' E) which is 3 Km away from the rural station Ramanandnagar and also at 5 Km East from rural station Ramanandnagar (17° 4′ N 74° 25′ E). Air ion concentration are measured first time in India during the weekdays (Monday-Saturday when all industries are working and more vehicles, human activities on the road) and week ends (Only Sunday when industrial working stopped, all offices, schools are closed and very less motor vehicles, human activities on the road). Also the ratio of positive to negative small ion ratio, which indicator of pollution at rural station, is studied.

MEASUREMENT SITES AND METHODS

The observational place Ramanandnagar (17° 4′ N 74° 25′ E) is surrounded by some tree groups (about 80-90 trees in radius of 120 m), grass land and agricultural land. The backyard is open agricultural land with sugarcane, wheat and corn fields. It is 210 Km southeast of Pune (18° 32′N, 73° 51′E) and 370 Km southeast of Mumbai (18° 55' N, 72° 54' E). The river Krishna is flowing just 4 Km to the west. A 20 feet road with an average traffic frequency of about 1-2 motor vehicles per minute are at a distance of 50 feet in front of the monitoring station at Ramanandnagar. The monitoring station is covered with sugarcane and corn crops from July to September 2007. Some crops except sugarcane are cut down and final products are obtained in the month of October 2007.

Figure 1. Small air ion counter, with: Power Supply, Fan, Electrostatic shield, Digital Voltmeter, Data Logger, and Personal Computer.

The apparatus consists of Gerdien condenser (Gerdien, 1905) which is shielded from external fields by co-axial cylinder fitted around the outer electrodes with Bakelite spacers in between (Figure 1). Central electrode is electro-statically separated from the fan by non-magnetic stainless-steel greed. Collecting electrode is at a virtual ground potential because of very high input resistance of the femtoamperemeter. Operational amplifier (AD549LH) was utilized for the conversion of the initial current to the potential signal, convenient for further processing and storage in computer memory. For fixed bias voltage, the ion current flowing through inner electrode is proportional to the ion concentration.

Observations of positive and negative air ion counts have been made in winter, pre-monsoon, monsoon and post-monsoon seasons in both week days and week end days (1 June 2007 – 31 May 2008). Positive ions are measured on 30 December 2007 (week end) and 1 January 2008 (week day) in winter seasons. Observations are made on 21 March 2008 (week day) and 23 March 2008 (week end) in pre-monsoon season. In the monsoon season, 14 July 2007 (week day) and 15 July 2007 (week end) are selected. Positive air ions are measured on 30 September 2007 (week end) and 1 October 2007 (week day) in post-monsoon season. Similarly, negative air ions counts are measured on 20 January 2008 (week end) and 21 January (week day) in winter season. In pre-monsoon season, 10 April 2008 (week day) and 13 April 2008 (week end) are to be selected. In the monsoon season, observations are made on 19 July 2007 (week day) and 22 July 2007 (week end). In post-monsoon season, negative air ion count measurements are made on 7 October 2007 (week end) and 8 October 2007 (week day). Note that it is not possible to measure positive and negative ion concentrations simultaneously at a time. Therefore we have measured the air ions of particular kind that is positive or negative ion on alternate days or epoch according to convenience. For the convenience for plotting the graph average air ions in Y-axis is taken as 10^2 ions cm^{-3} and are summarized in bar diagrams. In this measurement Monday to Saturday are considered as week days and Sunday is considered as week end day. The data have been collected during the period from first June 2007 to 31 May 2008; the period under analysis involves 8,040 hours

RESULT AND DISCUSSIONS

In the winter curve of positive ions (Figure 2c) fluctuations are smooth with variable interment. These fluctuations are noisy in character and may be attributed to sensitive nature of voltage type of fluctuations. However, the values of positive ions vary between 2×10^2 to 12×10^2 ions cm^{-3} and stable values are confine to $6\text{-}8\times10^2$ ions cm^{-3} irrespective of day and night. The pre-monsoon curve (Figure 3d) is smooth but with small fluctuations. The values vary between 0.1×10^2 to 2×10^2 ions cm^{-3} with night time low and day time also low values. The positive ion curve (Figure 2a) in the monsoon period due to variation of wind speed and rain fall there is saw tooth oscillations, the values vary around $1\text{-}5\times10^2$ ions cm^{-3}. In the Post-monsoon as shown in the curve (Figure 2b) is similar to pre-monsoon curve but with day time fluctuations are seen. The value varies between 2×10^2 to 5×10^2 ions cm^{-3}.

The variability of negative ion count (Figure 3c) varies slightly those of positive ion values. In winter, they are high in day time (7.5 units) and low (6 units) during night. The curve is rather smoother in this case than that of the positive ions in the same season (Figure 2c). In the pre-monsoon (Figure 3d) the curve of negative ion is similar to that of positive ions (Figure 2d). The values generally vary between 0.5 and 2 units, with low values around 11:00 hours and high values around 18:00 hours. In monsoon season (Figure 3a) the negative ion counts generally fluctuate vigorously. The reason for this may be due to the high humid and windy weather conditions. The curve shows smooth and flat during night time and the value is around 2.5×10^2 ions cm^{-3}. While during day time, fluctuations are well marked and oscillate between 1 to 3.5 units. In the post-monsoon (Figure 3b) the curve of negative ions shows a typical trend of bell shape pattern during day time. The value varies from 4 to 12×10^2 ions cm^{-3} the lowest value being at night and the highest value being at day 13:00 hours.

As shown in the curve 2 (c) in the winter at 00:00 hours positive air ion count is 7.75×10^2 ions cm^{-3} during week end and 9×10^2 ions cm^{-3} during week days. In the pre-monsoon (Figure 2d) at 20:00-24:00 hours positive ion count is below 1×10^2 ions cm^{-3} during week end and increases above 1×10^2 during week days. In the monsoon (Figure 2a) positive ion count is below 3×10^2 ions cm^{-3} (except one or two time) during week end and nearly equal to 3×10^2 ions cm^{-3} or above 3×10^2 ions cm^{-3} with few bursts during the week day. In the post-monsoon (Figure 2b) positive ion count is nearly varies around 3×10^2 ions cm^{-3} during week end and nearly around 4×10^2 ions cm^{-3} during week days in the afternoon period.

As shown in the Figure 3c in the winter during the afternoon negative ion count above 7×10^2 ions cm^{-3} during week end and below 7×10^2 ions cm^{-3} during week days. In the pre-monsoon (Figure 3d) during the week end negative cluster air ion never reaches to 0.1×10^2 ions cm^{-3}, while during week days negative ion count approaches to 0.1×10^2 ions cm^{-3} at 08:30 hours. In the monsoon (Figure 3a) similar variation of negative ions is observed during both week end and week days. In the post-monsoon during (Figure 3b) week end negative ion peak value reaches to 12×10^2 ions cm^{-3}, while during week days negative ion peak value reaches to 11×10^2 ions cm^{-3}. Air ion variation which is shown in Figure 2 and Figure 3 is not accidental readings but with vey small difference nearly same variation is observed in all the seasons (1 June to 31 May). All the collected data thought the year is summarized as positive to negative ion ratio in bar diagram (Figure 4)

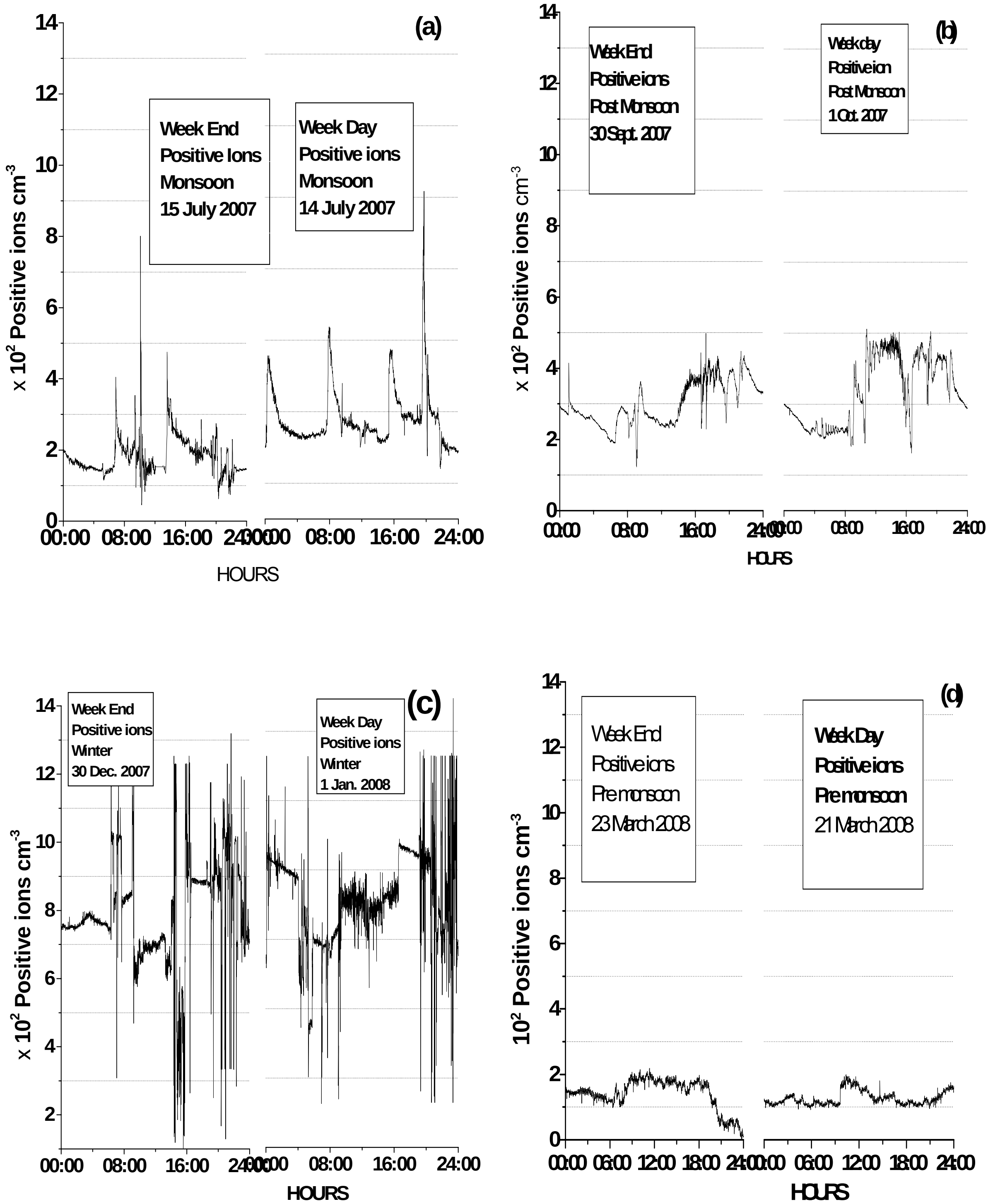

Figure 2. Seasonal variation of positive air ion concentration during week day and week end

Nearly all of the airborne particles such as dust, bacteria, chemical pollutants, and the particles of moisture are positively charged particles(Gabbay, 1990) in which they are frequently trapped that affect the human health. Usually, these are repelled from settling out on positively charged interior surfaces and remain well-mixed with air due to Brownian motion, unless they are magnetically attracted by negative small air ions and are neutralized. Finally these neutral particles settle out as visible dust on horizontal surfaces to the point where gravity become dominant force. Figure 4 shows that average positive to negative ion ratio which is pollution indicator is more during the week days as compared to week end for all the seasons. This means week end healthier as compared to week days. During the week end positive small air ion count is low as compared to week days. While during week end negative small air ion count is very high as compared to week days, which is observed in all seasons. This indicates that more aerosols produced from the various processes during the week days and hence more positive small air ions (Dua *et al*., 1978) are produced. Similarly during the week ends majority of offices, industries and schools are closed, therefore vehicles frequency on the road is less. This results very small amount negative air ions are combined with positive air ions and aerosols. Therefore during week end negative air ion concentration is high as compared to week days. Post monsoon is the transition period during which few thunder storms are observed due to these thunder storms additional amount negative ion are introduced and positively charged aerosols are cleared from the atmosphere. Therefore in the post-monsoon negative air ion count is high as compared to all other seasons

During the week end average positive to the negative small ion ratio decreases because the air ion production rate from Radon isotope (Prasad *et al*., 2005) which is generated from soil, plant transpiration is higher than the ion-to-ion recombination rate and ion-aerosol attachment rate (Herve *et al*., 2008). Due to friction between two air levels or air and any body negative ions are removed from the air and excess of positive ions are created. Also due to traffic frequency, combustion, air conditioning system, industrial west, press machines, aerosols are produced and these positively charged aerosols are combined with negative small air ions.

Hot or cool air forced through the duct work of most central heating and air conditioning system sets up friction that results in the loss of almost all the negative ions and also draws most of positive ions out of the air as well. Therefore average positive to negative small ion ratio maximum is observed during week days (Figure 4). Air with some positive and virtually no negative ions is forced out through vents into rooms, offices and passages and as it passes through the vents more friction is set up that generates an additional overload of positive ions (Soyka, 1977). Finally due to gravity of Earth, these aerosols are settling down on the ground and more negative air ions are removed from the atmosphere (Lohr and Pearson-Mims, 1996). Therefore average positive to negative air ion ratio is maximum during weekdays as compared to week end in the all the seasons (except 12:00-14:00 in Pre-monsoon) and in all months of the year. In the monsoon period June-September more rainfall during the afternoon and more aerosols are settled down on the ground. At the same time due to splashing water from rain showers, waves from the flooded Krishna-River more negative ions are produced in the atmosphere. Therefore only in the monsoon average positive to negative ion ratio is maxima for the time period 00:00-02:00 further decreases in the morning and reaches minimum for the time period 12:00-14:00 (Figure 4a). There is no rain in all remaining seasons except monsoon more aerosols are produced and more negative ions are removed from the atmosphere. Due to plant transpiration (Guedalia *et al*., 1970) of Radon-222 and Thoron-220 and its decay products small air ion concentration is very high at noon time. This diurnal pattern is reflected because the highest flux of Radon-222 due to evapotranspiration peaks middy are masked by concurrent strong vertical eddy mixing induced by strong solar heating because of the very short (56s) half life of Thoron-220 limited to grasslands, croplands and other shallow rooted vegetation (Raney and Vaadia, 1965). Therefore during post monsoon (Figure 4b), winter and summer average positive to negative ion ratio is minimum during midnight (00:00-02:00), further increases in morning (06:00-08:00) and reaches maximum during the afternoon (12:00-14:00).

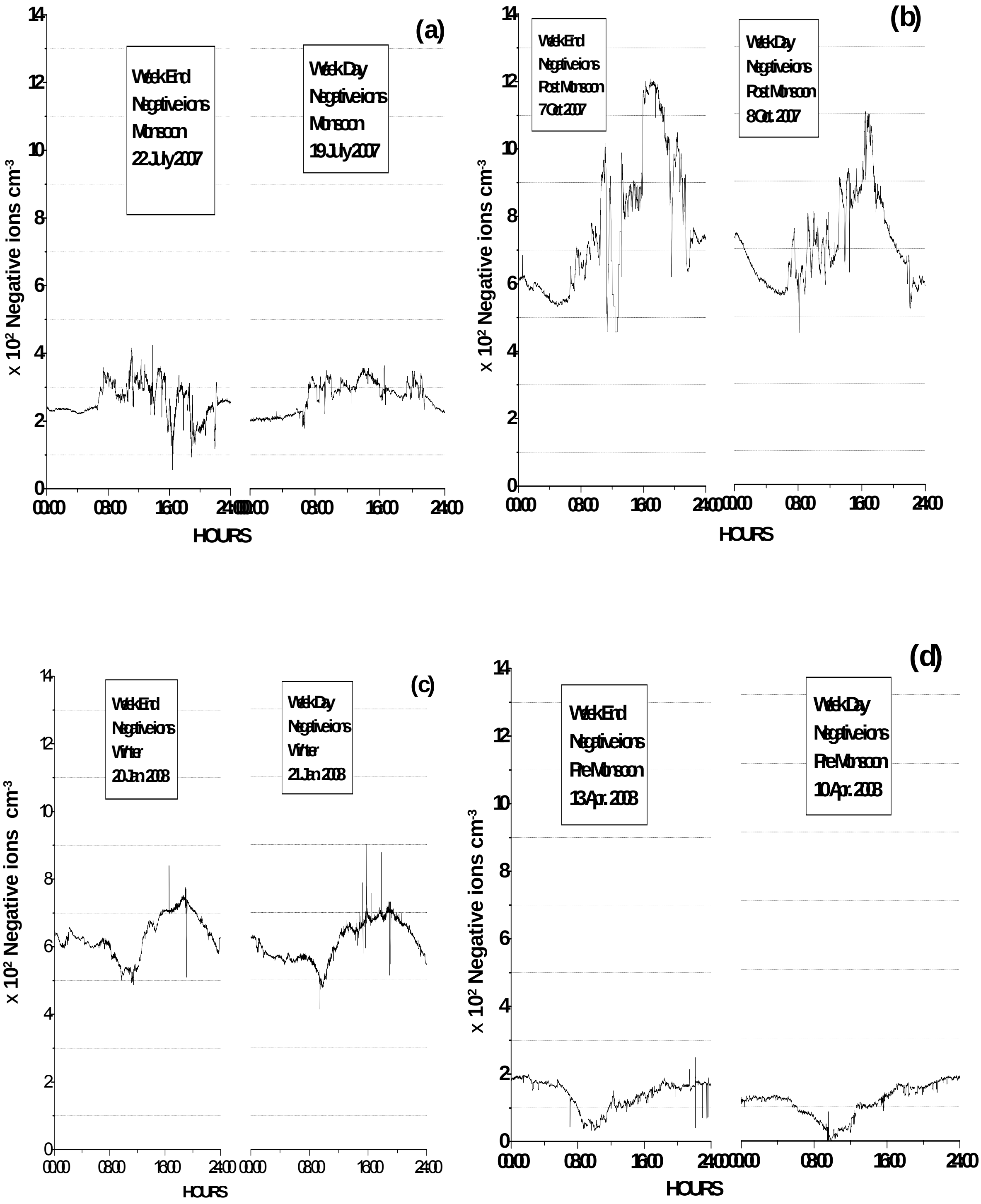

Figure 3. Seasonal variation of negative air ion concentration during week day and week end at rural station Ramanandnagar (17° 4′ N, 74° 25′ E)

As there is additional burden of aerosols in the atmosphere and there is no rainfall in the pre-monsoon, therefore more negative air ions are removed from the atmosphere. Due to these reasons only in the pre-monsoon it is observed that average positive to negative air ion ratio is same for week day and week end in the afternoon (12:00-14:00) (Figure 4d). In the winter due to low temperature Radon and Thoron gases are accumulated near the ground surface, which produces additional small air ion pair. Therefore average positive to negative ion ratio varies between 1-1.5 during all the time period (Figure 4c).

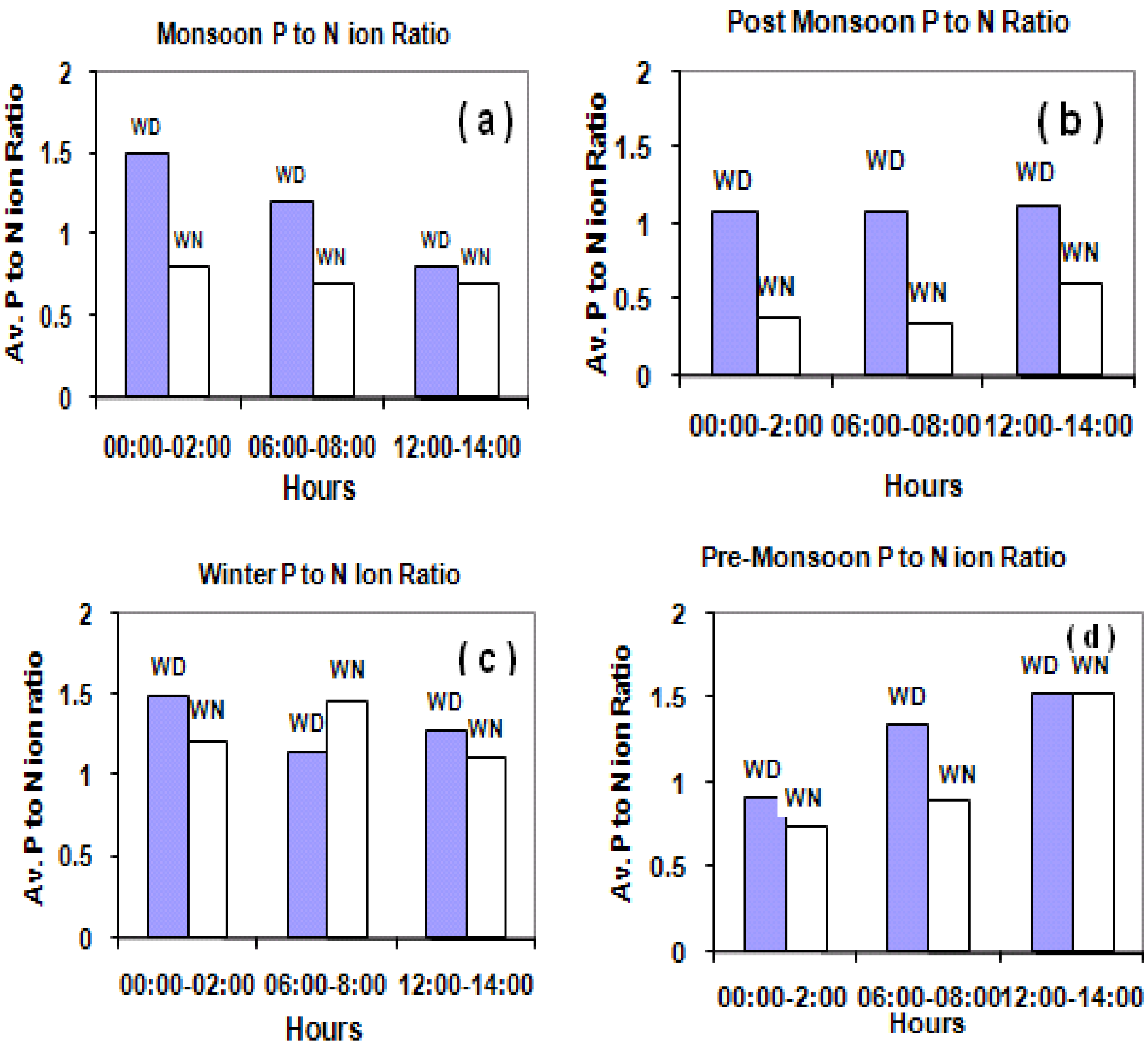

Figure 4. Seasonal variation of positive to negative cluster air ion ratio during the week day and week end for 00:00-02:00, 06:00-08:00 and 12:00-14:00 hours

At the rural site Ramanandnagar (17° 4′ N, 74° 25′ E) the area around the monitoring station is crops of sugarcane, corn, etc. Therefore plant transpiration (Guedalia *et al*., 1970) comes in the picture. Plant transpiration produces Radon and Thoron gases (Allen *et al*., 1964), which in turn produce ion pair production. Therefore air ion count curve of both the polarities increases from early morning and reaches to maximum at noon time rather than night (Israel, 1965, 1969).

CONCLUSIONS

As all the dust, aerosol, bacteria, etc. are positively charged and attracted magnetically by negative air ions, which are neutralized and settled down on the ground. These results deplete negative small air ions; therefore, average positive to negative ratio which is pollution indicator is high during week days as compared to week end. Not only have that but also positive ion maxima are very high magnitude during week day as compared to week ended. At the same time negative small air ion maxima are observed very high magnitude during week end. As the atmosphere is clean during the week end as compared to week day which is more polluted. During the week end positive small air ion count is low as compared to week days. While during week end negative small air ion count is very high as compared to week days, which is observed in all seasons (1June 2007 - 31 May2008). This indicates that more aerosols produced from the various processes during the week days and hence more positive small air ions are produced. Similarly during the week ends majority of offices are closed, therefore vehicles frequency on the road is less. This results very small amount of negative small air ions are combined with positive small air ions. Therefore during week end negative small air ion concentration is high as compared to week days.

Due to very low temperature during winter seasons Radon and Thoron gases are accumulated near the ground surface, which produces additional small air ion pair. Therefore positive and negative small air ion count maxima are observed during the winter both in week days and week end (Dhanorkar and karma, 1992; Debaje *et al*., 1996; Prasad *et al*., 2005). Post monsoon is the transition period during which few thunder storms are observed due to these thunder storms additional amount of negative ions are introduced and positively charged aerosols are cleared from the atmosphere. Therefore in the post-monsoon negative small air ion count is high as compared to all other seasons. The diurnal variations of small air ions are detected at a rural station Ramanandnagar (17° 4′ N, 74° 25′ E) has never been observed elsewhere.

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