AIR ION VARIATION IN WINTER SEASON AT URBAN STATION SANGLI (17° 4' N 74° 25' E) AND RURAL STATION RAMANANDNAGAR (17° 4' N 74° 25' E) INDIA

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ABSTRACT

In the atmosphere ions diffuse to aerosol particles and transfer their charge to the particles. In rural areas, the auto-mobile exhaust or other human activity cause introduction of large concentration of aerosol particles in the atmosphere. At urban station there are lmitited sources for the production of air ions, at the same time produced air ions are consumed by aerosol in the atmosphere.Therefore their concentrations in the atmosphere show large spatial and temporal variations. 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 and urban station Sangli. At urban station positive air count varies in the range 2-3 $x10^2$ ions per cm3, while positive air count at rural station varies in the range 5.5-8 $x10^2$ ions per cm3. Negative air ion count varies in the range 0.7-1.5$x10^2$ ions per cm^3 at urban station, while it varies in the range 5-7.9$x10^2$ ions per cm^3 at rural station. Such highly depleted negative ions and more concentrations of positive ions at urban atmosphere could trigger allergic respiratory disease and also decline in lung function. As compared to urban station rural station is healthy for human health.

Keywords: Air Pollution, Air Quality, Aerosol, Cluster ion, plant transpiration.

1. Introduction

The production of atmospheric ion from the process of ionization takes place through three steps: ionization, attachment and clustering. Ionization is a process in which an electron is released from the outer electron shell of gas molecule or atom. An electron detached from a molecule or atomic bond, cannot exist freely in air at normal temperature and pressure, but readily attaches itself to neutral atom or molecule. However even these molecular or atomic ions cannot remain stable in atmospheric air at normal condition, and consequently surround themselves with a number of neutral molecules and form clusters of approximately 10-30 molecules. Only then do they reach certain stability in the form of so called Cluster ions.

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 depend on the amount of ^{222}Rn in the ground; the type of ground cover, porosity and temperature of soil (Hoppel *et al* 1986). There are several man made sources of ionization such as the exhaust from automobiles or aircrafts, industrial processes etc. some of these are discussed by Kamra (1991). Contributions of such local sources to the ion concentration of the atmosphere may be dominant in the neighborhood of such activities.

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). 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).

The goal of this paper is to provide such data and to interpret these observations with regard to our current knowledge on atmospheric ion and aerosol dynamics. In this study the ion concentrations are measured at urban station Sangli and rural station Ramanandnagar which helps us to understand the plausible mechanism by which the ions generate and inject in to the Earths atmospheric boundary layer. By measuring air ion concentration at urban and rural area, we also try to highlight, which atmosphere is harmful for human health. To compare urban and rural area for healthy atmosphere air ions were measured at two stations in winter season.

2. Measurements and methods

Terrain surrounding the observatory at rural site some tree groups (about 80-90 trees in radius of 120 m) small woods, grass land and agricultural land (Pawar *et al* 2012). The backyard where outdoor observations are conducted is open agricultural land with sugarcane, wheat, corn fields. Observatory at Ramanandnagar with co-ordinates is located in sparely populated rural region. It is 210 Km southeast of Pune (Fig.1) and 370 Km southeast of Mumbai capital of Maharashtra (India). The river Krishna flows just 4 Km to the Northwest. A 20 feet road with an average traffic frequency of about 1-2 motor vehicles per minute close to the observatory (Pawar *et al* 2011). The observatory, in which we carried out the measurements, is located in the ground floor. The room was used for measurement of air ion concentration. At other times; there were no indoor activities in the laboratory. The floor area and volume of laboratory were 10 m^2 and 42m^3 respectively. The overall surface area (floor, walls, ceiling and the surface of tables and cabinets) of the laboratory was approximately 63m^2.

Figure 1: Air quality monitoring stations at Ramanandnagar (rural) and Sangli (urban) in India.

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 (Fig.1). 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.
Sangli is situated in the river basins of the Warna and Krishna rivers. The valley of the River Krishna and its tributaries is one of the greenest areas of the country. Other small rivers, such as the Warana and the Panchganga, flow into the River Krishna. The Sangli region is known as the "Sugar Belt of India".

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. 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 data collected from January 2011 to February 2011.

3. Result and discussions

At rural station Ramanandnagar positive air ion count at 00:00 hours was 7.5x10^2 ions per cm3 (Fig 2a). It starts decreasing and reaches minimum (5.5) at 10:30 hours. Positive air ion count starts increasing from 10:30 hours and reaches maximum 9.8) around 18:30 hours (Fig. 1a). From 10:30 hours again starts decreasing and reaches minimum (6.5) at 24:00 hours. At Urban station Sangli positive air ion count was 2.5 at 00:00 hours. As compared to rural station at urban station positive air ion count varies smoothly (Fig. 1b). At urban station positive air count varies in the range 2-3 x10^2 ions per cm^3, while positive air count at rural station varies in the range 5.5-8 x10^2 ions per cm^3.

At rural station negative air ion count was 6.5 x10^2 ions per cm^3 at 00:00 hours (Fig.2b). The valley type negative air ion variation observed during 00:00-02:00 hours. Negative air ion count starts decreasing from 02:00 hours and reaches minimum (5) at11:00 hours. Again starts increasing and reaches maximum (7.9) at 18:20 hours. Negative air ion count again starts decreasing from 18:30 hours and reaches minimum (6) at 24:00 hours (Fig. 1c). At urban station negative air ion count was 0.7 x10^2 ions per cm^3 at 00:00 hours, starts increasing and reaches maximum 1.5 x10^2 ions per cm^3 at 07:30 hours. It varies smoothly during all the time period (Fig.1d). Negative air ion count varies in the range 0.7-1.5 x10^2 ions per cm^3 at urban station, while it varies in the range 5-7.9 x10^2 ions per cm^3 at rural station. 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 rural site, magnitude of negative air ions is very low at urban station Sangli. 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 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).
positive air ion count was maximum (3) during 00:00-02:00 hours. The minimum (2.2) of average positive air ion count was observed during 12:00-14:00 hours. Average positive air ion count was 2.7 x10^2 ions per cm^3 during 06:00-08:00 hours (Fig. 3b).

At urban station average negative air count maximum (1.5) was observed 06:00-08:00 hours and minimum (0.8) was observed 00:00-02:00 hours (Fig.3d). Average negative air ion count was 1.2 x10^2 ions per cm^3 during 12:00-14:00 hours. This indicates that negative ions are attached to the aerosol particles and larger aerosol particles are produced from the smaller aerosol particles (Gabbay, 1990, Shiue *et al.,* 2011). At rural station average negative air ion count varies in the range 5.8-6 x10^2 ions per cm^3 (Fig.3c), while in the urban station varies in the range 0.8-1.5 x10^2 ions per cm^3 (Fig. 3d).

Average positive air ions are above 2 x10^2 ions per cm^3 and avearge negative air ions below 2 x10^2 ions per cm^3 at urban station. Average positive air ions are above 6.2 x10^2 ions per cm^3 and avearge negative air ions below 6.1 x10^2 ions per cm^3 at rural station. Average positive air ions varies in the range 6.5-9.2 x10^2 ions per cm^3 at rural station and 2.1-3.2 x10^2 ions per cm^3 at urban station. Average negative air ions varies in the range 6-6.2 x10^2 ions per cm^3 at rural station and 1.096-1.47 x10^2 ions per cm^3 at rural station.

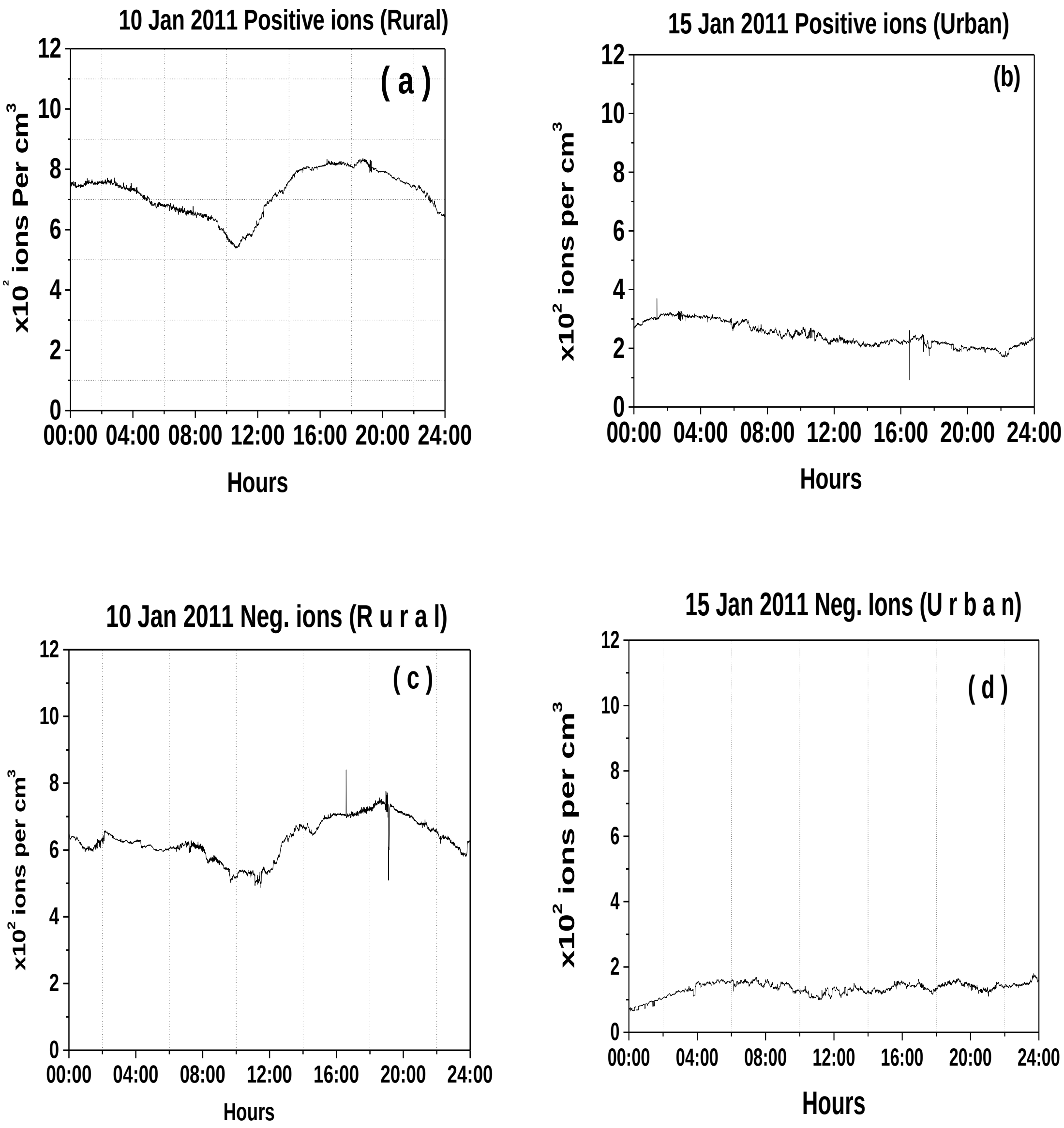

Figure 2: Comparison of air ion variation at rural station Ramanandnagar and urban station Sangli.

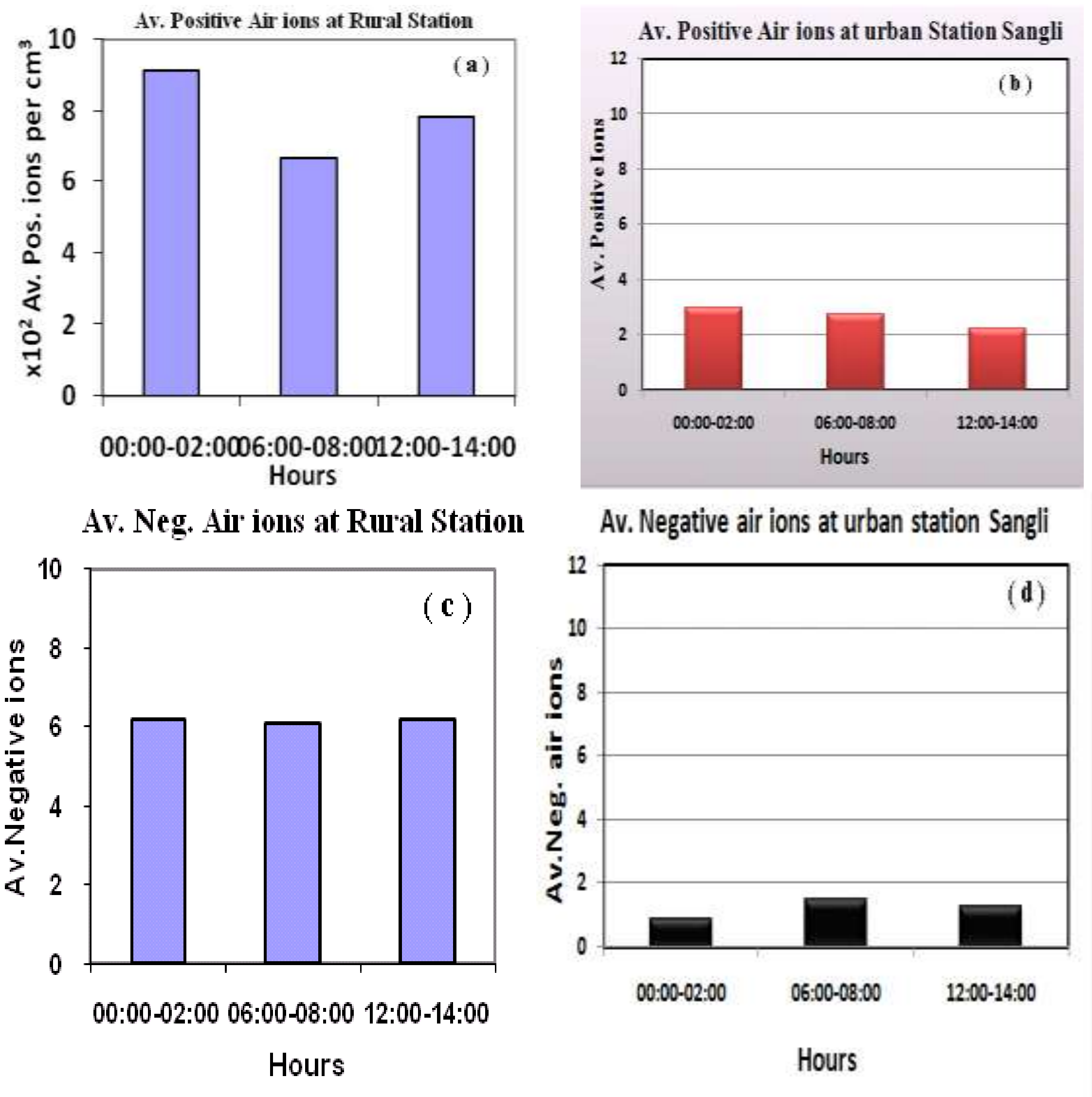

Figure 3: Comparison of average air ion variation at rural station Ramanandnagar and urban station Sangli.

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).Therefore, the regions such as urban place like Sangli where the concentrations of aerosols are high and associated air ions become low. At a clean atmosphere place like rural station Ramanandnagar, the concentrations of aerosol particles are low and as a result the concentrations of air ions are high (Herve *et al*., 2008).

At rural station average negative ion maximum (9) observed during 00:00-02:00 hours and minmum is observed during 06:00-08:00 hours (Fig. 3a). Average negative air ion count was 7.7 $x10^2$ ions per cm^3 during 12:00-14:00 hours.At urban station average

4. Conclusions

At urban station positive air count varies in the range 2-3 $x10^2$ ions per cm^3, while positive air count at rural station varies in the range 5.5-8 $x10^2$ ions per cm^3. Negative air ion count varies in the range 0.7-1.5 $x10^2$ ions per cm^3 at urban station, while it varies in the range 5-7.9 $x10^2$ ions per cm^3 at rural station. Average positive air ions varies in the range 6.5-9.2 $x10^2$ ions per cm^3 at rural station and 2.1-3.2 $x10^2$ ions per cm^3 at urban station. Average negative air ions varies in the range 6-6.2 $x10^2$ ions per cm^3 at rural station and 1.096-1.47 $x10^2$ ions per cm^3 at urbanl station. As there are limited sources for the production air ions in the urban station, therefore air ion concentration of both the polarities were low. At rural station plant transpiration is additional source for the production air ions, therefore air ion concentration of both the polarities were high. Therefore as comparied to urban atmosphere rural atmosphere is very healthy for human health.

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