Variation in atmospheric air ion and its index of pollution during morning time (06:00 to 08:00 IST) in the sugarcane area at rural station Bhilawadi (16.5°N, 74.2°E)

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Abstract: The present paper reports the diurnal variation in +ve and –ve air ion concentration and pollution index in a sugarcane field [genus: Saccharum spp., variety: CO86032 (NAYANA)] in the vegetation area situated at rural station Bhilawadi (16.5°N, 74.2°E), India. It is a hybrid variety of CO62108 and CO671. The outcomes introduced in this investigation propose that the open ecological air or particularly the sugarcane zone shows enormous convergence of –ve air ions which are basic for human wellbeing. It is due to ionisation, photosynthesis, transpiration and radon exhalation process by sugarcane. The results presented in this study suggest that the open environmental air or especially the sugarcane area exhibits large concentrations of –ve air ions which are essential for human health. Though all living beings interact with the environment, only human beings have less interaction with the environment, so attempts should be made to use natural resources to have better health.

Keywords: air ions; sugarcane; radon; ionisation; transpiration; environment; pollution index.

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1 Introduction

All airborne particles in the environment with electrical conductivity and charge (+ve and –ve) are known as air ions. Air is a mixture of different gases. Natural air ions are generally produced in many ways such as gamma rays, natural radioactivity, cosmic rays, waterfalls and wind motions (Krueger and Reed, 1976). Ionisation, attachment and clustering are three phases for stable forms of ions. When an atom loses or gains electrons then it is said to be positively or negatively charged ion, respectively. This process is called ionisation. For an atom or molecule which is electrically neutral and balanced, it is said to have an equal number of protons and electrons. Losing an electron, atom or molecule becomes +ve ion whereas gaining becomes –ve ion. The concentration of such air ions (both +ve and –ve) in the atmosphere affects human health. Depending upon their proportion and concentration, they may be beneficial as well as harmful for humans. The discomforts like headache, fatigue, nervousness, high blood pressure, joint aches and decrease in work productivity are due to the presence of higher +ve ions in the air. On the other hand, –ve air ions have +ve effects on human health. The negative air ions are beneficial for human health in the context of their mind as well as immunity level. We feel happy, relaxed and breathe easy in the presence of –ve air ions. The chemical called serotonin present in the blood may get reduced under the exposures of negatively charged atmospheric air ions (Diamond, 1988). Ions have antibacterial effects which decrease allergens and a number of microorganisms in the air.

Several researchers in the past have studied the air ion concentrations, their variability and production rate. The diurnal air ion concentrations in the atmosphere, aerosols, ozone, etc. have been measured from Belgrade (44°50′N, 20°37′E) by Kolarz and Filipovi (2008). Their analysis shows that the air ions both +ve and –ve as well as ozone concentrations are directly proportional to each other. On the other hand, the aerosols have a strong opposite correlation with that of air ions. Pawar et al. (2010) studied the season wise as well as day wise variations in air ions using a Gerdien condenser during June 2007 to May 2008 at one of the rural places Ramanandnagar which is located in Sangli District and at urban place Pune which is a tropical region. Their study suggests that, the air ion concentrations measured at Pune station found to be increased from night time and reached maximum in the early morning. Pawar (2013) utilised Gerdien condenser air ion counter for measurement of air ions variation according to meteorological parameters such as temperature, relative humidity, etc. The air ions in the atmosphere can also be generated due to lightning during thunderstorms. Subramanian and Jagadesan (2014) measured air ion concentrations produced in Pudukkottai district (10.23°N, 78.52°E) of Tamil Nadu, India and found that the production of air ions during the occurrence of lightning and thunder has enhanced the process of photosynthesis (i.e., production of starch) by green plants and crops. The radon concentration is found to be maximum in the lower portion of the troposphere (0–5 km). The daily cycle of air ion variation is owing to the ionisation process triggered through cosmic waves as well as energetic minerals present in the atmosphere. However, some changes can also occur due to changes in radon concentrations. Sugarcane is the crop which needs more water for its cultivation. The radioactive gas which is naturally present or produced in air is nothing but ^{220}Ra. It is a daughter nuclide of ^{226}Ra. This radon can be drawn out through smaller pores of soil and ultimately exposed into the atmosphere.

The aim of the present paper is to measure air ion concentration in the sugarcane area at rural station Bhilawadi and study the effect of sugarcane field on the air ion production rate as well as pollution index.

2 Instrumental description

The air ion counter used in the present study is indigenously developed at A.C.S. College, Palus by Patil et al. (2019). A small air ions present in the atmosphere have been measured by Gerdien condenser during campaign observations. It is shielded from outside using a coaxial cylinder fixed with bakelite spacers. A brass sheet as well as chrome plate is used to make this condenser. A suction pump is fitted to a condenser via coaxial cylinder which sucks up the air particles in the atmosphere (Harrison, 1992). The rate of the air flow in the condenser is easy to vary by just adjusting the voltage of the suction pump. Anemometer (AM-4201) is a device used for the measurement of velocity of air molecules. This Anemometer is sensitive and has accuracy of 0.005 m/s. An operational amplifier (AD549JH) is utilised to transform current measured in the data logger (ref. Figure 2).

Now, the flow rate (∅) can be given as,

$$\varnothing = v\pi\left(r_o^2 - r_i^2\right)$$

where r_o is the radius of the external cylinder and r_i is the radius of the internal cylinder. Now, air ion concentration denoted by N can be written as,

$$N = I / (e\varnothing)$$

In the above equation, I depicts the initial current given and e depicts the ion charge which is 1.6×10^{-19}C.

To measure air ion concentrations of the atmospheric species such as +ve and –ve ions, the polarity of the circuit can be changed. A personal computer with voltmeter and data logger is used to store the continuous data. Also, Rishcom software is used for data acquisition.

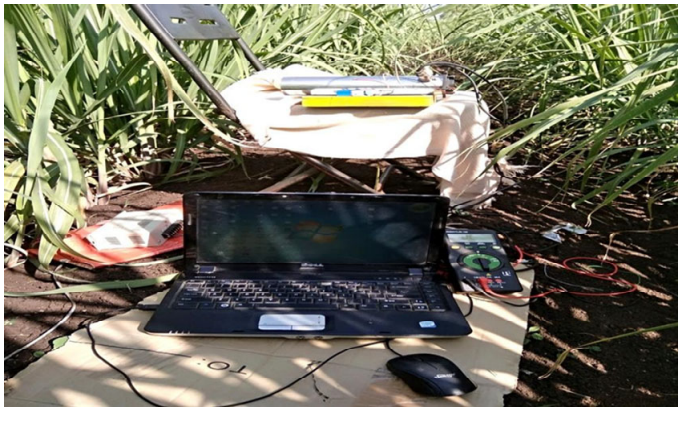
3 Measurement and methods

The campaign observations were carried out in a sugarcane field at Bhilawadi (16.5°N, 74.2°E) which is located in the rural area of Palus Tehsil and Sangli District in Maharashtra State. There is a river named 'Krishna' which flows ~3.5 km away towards the northwest side from the location. There is a 90 feet high mobile tower stationed at a distance of 0.5 km from the observation location. Also, 10 feet road having average traffic of 2 to 4 motor vehicles in half an hour were there. The variety of sugarcane field in which the measurement is carried out is CO86032 (NAYANA) which is mostly cultivated in rural areas in Maharashtra (refer Figure 1 for sugarcane field). It is a hybrid involving CO62198 as female parent and CO671 as male parent. The experimental setup (explained in the next section) is kept in the middle of the sugarcane field for the measurement of air ion concentration. The +ve and –ve air ions have been measured during the period from 15 Oct. 2018 to 29 Oct. 2018 with time resolution of 30 seconds.

The average ions on a daily basis were estimated from collected data. The soil at the observatory is a complete black soil. It has an arrangement of supply of river water through irrigation systems. The unipolarity factor viz. the pollution index is also calculated for the sugarcane field. The pollution index can be defined as the ratio of average +ve air ions to the average –ve air ions. If this index is higher than unity, then it is risky and the density of aerosol will be higher in the atmosphere. For healthy human life pollution index should be less than 1 (Grinshpun et al., 2005).

Figure 1 The photograph of sugarcane field (variety: CO86032) in Bhilawadi (see online version for colours)

Figure 2 Experimental setup installed in the sugarcane field during campaign observations in Bhilawadi (see online version for colours)

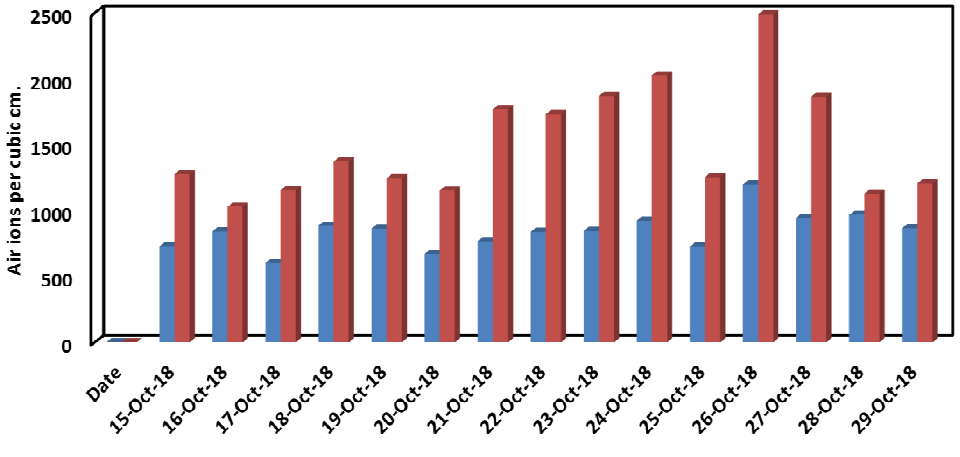


4 Result and discussion

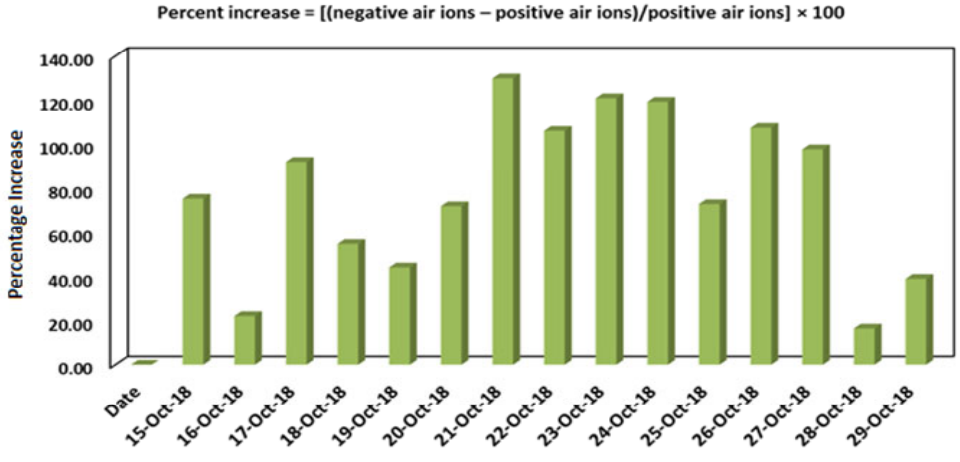
The air ion concentration of sugarcane CO86032 is measured continuously during 15 October 2018 to 29 October 2018. The air ion variation and pollution index of +ve and –ve air ions have been measured. Figure 3(a) shows the average +ve (blue bars) and –ve

(red bars) air ions during 24 hours of each day of observations. It is seen that the average numbers of +ve as well as –ve ions are in the same proportion. The concentration of –ve air ion is more than that of +ve air ion. This can be attributed to the sugarcane field wherein –ve air ions are dominant. We have also calculated the percentage increase in –ve air ions w.r.t. +ve air ions as depicted in Figure 3(b). The formula for percentage increase is, percent increase = [(–ve air ions – +ve air ions) / +ve air ions] × 100. This shows how –ve ions are varying w.r.t. +ve air ions in percent. It is seen that the percentage increase is dominant on 21st October 2018.

Figure 3 (a) Average +ve (blue bars) and average –ve (red bars) air ions during 24 hours of each day of observation (b) The green bars indicate the percentage in increase of the –ve air ions w.r.t. +ve air ions (see online version for colours)



(a)

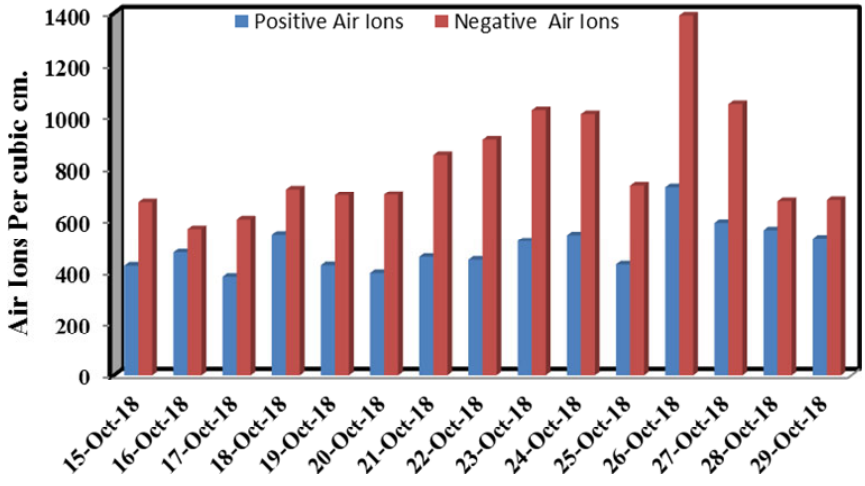


(b)

The average +ve and –ve air ions during 06:00 to 08:00 IST period are depicted in Figure 4 which also shows nearly the same increase in both the species. Actually, there is equivalence between +ve as well as –ve air ions throughout the day. Further, it shows that

numbers of +ve ions seem to be less with respect to the number of –ve ions. It also shows that the number of –ve ions increases with increase in +ve ions. In Figure 4, on 26 Oct. 2018, we can see the drastic increase in –ve ions unlike other days. This is due to the thunderstorms and small raining persisted on that day which results into the –ve air ion formation accompanied by corona effect. The strong electric field can be produced by applying voltage to a sharp ionising point to electrons which is used in corona ionisers. The +ve electric voltage accelerates free electrons towards a sharp ionising point (leaflet of sugarcane) in the atmosphere. These electrons are produced by decay of radioactive elements in air and soil. Due to collision between air molecules and electrons, number air ions were produced. When they lose electrons become +ve ions and by gaining electrons become –ve air ion. This is the corona effect which is dominant during thunderstorms. The daily maximum values of +ve and –ve air ions are plotted in Figure 5. It also shows a maximum peak of –ve air ion on 26 Oct. 2018. On the other hand, the minimum value of +ve air ions was noted on 17 Oct. 2018.

Figure 4 Average +ve and –ve air ions during 06:00 to 08:00 IST of each day of observation (see online version for colours)

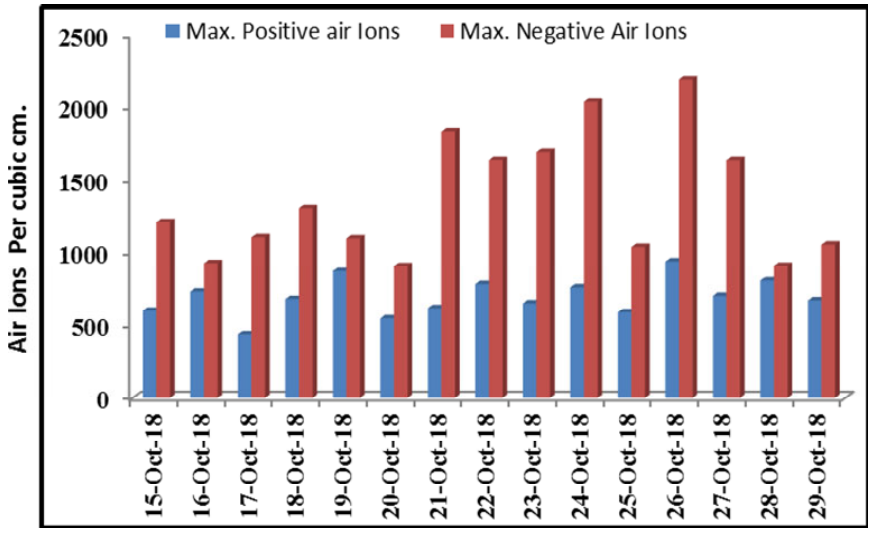


Radon gas gathers nearer to ground in a quiet atmospheric condition such as night time and also it is heavier than air (Jayaratne et al., 2011). The α-particle generated from Ra^{222} decay has energy of 5.4 MeV. This energy is adequate to generate 10^5 pairs of atmospheric air ions (Burcham, 1973). Thus, we can say that air ion density is directly related to the radon level. During dawn hours, the radon release expectancy is maximum in sugarcane vegetation. Due to which there is an increase in air ion concentrations in the sugarcane field.

In Figure 6, it is seen that the pollution index is below one which is best for human health and this indicates that the atmosphere in the sugarcane field is good for human health. In the morning period, we always see that workers, farmers and other field work labours have been working properly with energetic mood and freshness. The scientific reason behind this is that there are maximum numbers of –ve air ions are present during the morning period. This –ve air ions have +ve effects on human health such as delightful mood, peaceful sleep, more work productivity, etc. Also, it is beneficial to animals and

all living beings. The strong energy level as well as positive mood is accompanied by maximum concentrations of –ve air ions present in the atmosphere we breathe (Thayer, 1989). On the other hand, +ve air ions are responsible for discomfort, headache, high blood pressure, nervousness, etc. in human life. From analysis, the average pollution index for October month is found to be 0.59. The average count of +ve air ions was 845 ions per cubic centimetre and that of –ve ions was 1,505 ions per cubic centimetre. The upsurge in air ion concentration is associated with the plant transpiration of sugarcane area and also due to radon exhalation. From the present investigations, the sugarcane field is indeed found to be rich in –ve air ion concentration. During morning in most of the farms in rural area, we feel good and happy due to the large density of –ve atmospheric ions in the sugarcane field. They act as vitamins for humans. Photosynthesis is a process during which food material is synthesised from carbon dioxide and water in green plants with the help of chlorophyll in the presence of sunlight. CO_2 and H_2O act as raw materials. It is thus an oxidation-reduction process. This process involves many chemical and photochemical reactions. In this process, O_2 is given out.

Figure 5 Daily maximum and minimum +ve and –ve air ions during 24 hours of each day of observation (see online version for colours)



A simplified overall formula for photosynthesis is given by Brown et al. (1977) as follows:

$$6CO_2 + 12H_2O \xrightarrow[\text{Light energy}]{\text{Chlorophyll}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

In the respiration process, O_2 is taken in and CO_2 is released in the air. But in the transpiration process, water is released in the form of water vapour which includes radon also. Due to the release of radon through stomatal or cuticle transpiration, there is a production of air ions in the vicinity of plants (e.g., sugarcane). The process of transpiration and photosynthesis increases with temperature. So it observed an increase in

the ions formation after 7:00 hours and so on. The effectiveness of plant transpiration of ^{222}Rn and ^{220}Rn is due to its concentration in the soil, gas and solubility in water. The water solubility of radon is higher at low temperature. 222 Ra exhalation from soil and leaves of sugarcane fields have exponential growth. The radioactive decay sequence of 222 Ra is given by Martell (1985) as follows:

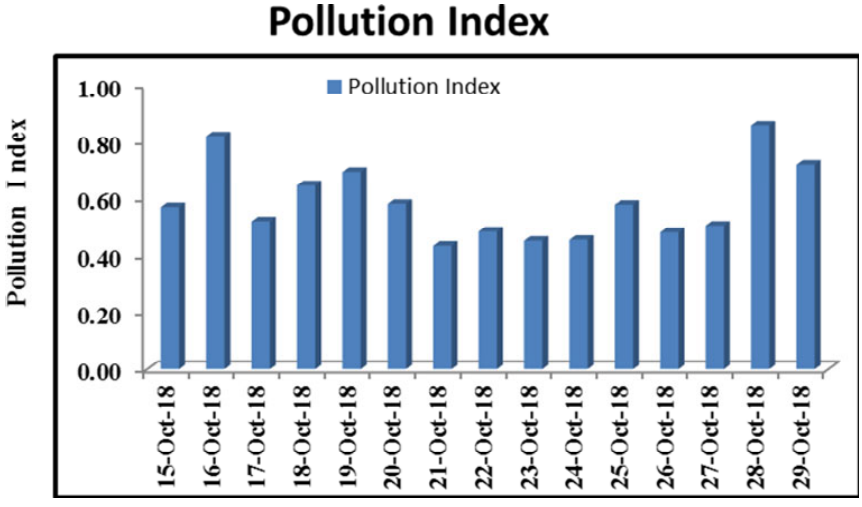
$$\overset{\alpha \quad \alpha \quad \beta^-, \gamma}{^{222}\text{Rn} \rightarrow {}^{218}\text{Po} \rightarrow {}^{214}\text{Pb}}$$

(3.8 days)(3.5 min)(27 min)

$$\overset{\beta^-, \gamma \alpha \quad \beta^-, \gamma}{^{222}\text{Bi} \rightarrow {}^{214}\text{Po} \rightarrow {}^{210}\text{Pb}}$$

(19.7 min)(0.0016 sec)(22 years)

Figure 6 Pollution index calculated on each day of observation (see online version for colours)



Jesse and Sadaukis (1957) reported that the average energy necessary to generate one air ion pair for alpha particles is nearly 35 eV. And for beta particles, X-rays and γ-rays this energy is 33.8 eV. In ^{222}Rn disintegration, 6.4×10^5 air ions are produced. The radioactive decay sequence of ^{220}Ra is given by Martell (1985) as follows:

$$\overset{\alpha \quad \alpha \quad \beta^-, \gamma}{^{222}\text{Rn} \rightarrow {}^{216}\text{Po} \rightarrow {}^{210}\text{Pb} \rightarrow {}^{212}\text{Bi}}$$

(56 sec)(0.15 sec)(10 hr)(60 min)

$$\overset{\beta^-, \gamma \quad \alpha}{^{212}\text{Bi} \rightarrow {}^{212}\text{Po} \rightarrow {}^{208}\text{Pb}}$$

(64%) 0.30 μ*s*

^{220}Rn and ^{216}Po undergo (-particle and ®-particle emission till complete decay within the vegetation canopy. This is due to their very short half-lives. This production of air ions due to transpired radioisotopes is ten times more than the rate of air ion production by cosmic rays.

From this, it is clear that plant transpiration including stomatal as well as cuticle plays an important role in the increased value of air ion concentration. Also, radon generated in the Earth's crust produces air ions due to the radon exhalation process. In the photosynthesis process, sugarcane crops with increase in temperature produce air ions.

5 Conclusions

As air ions in the environment play an important role in human life so it is necessary to study air ion concentrations for different crops. We have measured +ve and –ve air ions by using indigenous ion counters. The average pollution index for the sugarcane field was found to be 0.59 at Bhilawadi during morning period 6:00 to 8:00 hours which indicates non-hazardous atmosphere. In sugarcane vegetation area, stomatal and cuticle plant transpiration plays vital roles for generation of air ions. Sugarcane area is a natural shower of –ve air ions. Hence, instead of using artificial air ionisers, it is always better to go in nature. We have observed remarkable enhancement in the air ion concentration in the sugarcane field in morning hours. Apart from development in numerous areas which is called as globalisation, the conservation of nature must be our moral obligation which will be beneficial to all living beings including humans and for future generations as well. The present study shows that the concentration of –ve atmospheric air ions in the sugarcane field is high during 06:00 to 08:00 in early morning hours. Generally, in the environment, sugarcane is an opportunity for air quality improvement and acts as a cash crop for farmers which are also useful for sustainable development. Basically, we observe that the farmers or workers are healthier than professionals and employers in urban or metro areas because farmers are in the vicinity of nature. They get fresh air which contains more –ve air ions. Indirectly, nature provides us healthy air full of –ve air ions associated with different vegetation. Thus, nature is a natural shower of air ions. Different crops give rise to different numbers of air ions at different time instances depending upon other meteorological conditions. Our future study is to measure air ion concentration in different vegetation areas and to find out which crop at what time exhibits healthier atmosphere for humans in the rural areas.

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