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# Influence of solar variability on rainwater

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The significant effect of the high-energy charged particles, entering the earth's environment from interplanetary space, on the space and terrestrial weather is well known. Solar flares emit electron particles. These electrons interact with Earth's magnetic field and atmosphere causing weather, geophysical and behavioural changes. These charged particles from the sun affect Earth's magnetic field and increase atmospheric nucleation which then affects cloud formation and thus the weather. Keeping this in view, a study has been undertaken to examine the changes in rainwater associated with the high energy charged particles entering the earth's environment from interplanetary space. It is observed from the analysis that an increase in proton and electron fluences is followed by an increase in electrical conductivity and decrease in pH of rainwater over Pune.

**Keywords:** Rainwater, Sunspot number, Electron fluence, Proton fluence

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## 1 Introduction

Svensmark[1] demonstrated changes in the heliosphere arising from fluctuations in the Sun's magnetic field. They have shown that galactic cosmic rays (GCRs) are less able to reach the Earth when the Sun is more active so the cosmic ray flux is inversely related to solar activity. Svensmark[1] using low cloud data between 60°S and 60°N from geostationary satellites found an increase in cloudiness of 3 to 4% from solar maximum to minimum and speculated that: (a) increased GCR flux causes an increase in total cloud; and (b) the increase in total cloud causes a cooling of climate. Svensmark[2] showed that total cloud varies more closely with GCRs than with the 10.7 cm solar activity index over the past solar cycle. Cosmic rays are the principal source of ionisation in the free troposphere. Furthermore, ionisation rates and atmospheric conductivity are observed to vary with solar activity. Svensmark[2] proposed that the correlation between cosmic rays and cloud cover is due to an increase in efficiency of charged particles, over uncharged ones, in acting as cloud condensation nuclei. Tinsley[3-6] has developed a more detailed mechanism for a link between cosmic rays and cloudiness. This is based on the premise that aerosols ionised by cosmic rays are more effective as ice nuclei and cause freezing of super cooled water in clouds. In clouds that are likely to cause precipitation, the latent heat, thus, released then causes enhanced convection which promotes cyclonic development and hence increased storminess. Svensmark[2] have indicated a possible mechanism via the influence of solar modulated cosmic rays on global cloud cover. Surprisingly, the influence of solar variability is strongest in low clouds (3 km), which points to a microphysical mechanism involving aerosol formation that is enhanced by ionization due to cosmic rays. If confirmed, it suggests that the average state of the heliosphere is important for climate on Earth. King[7] presented evidence which indicates that important climatic features, such as droughts and unusually long 'growing seasons', are dependent on the solar cycle to such an extent that significant progress could be made in forecasting the occurrence of these features if some account were taken of the expected levels of solar activity in the future. It has been also demonstrated that energetic particles may constitute one form of solar radiation which profoundly affects the lower atmosphere.

## 2 Data and Analysis

Rainwater over Pune was collected from 20 June to 30 July 2006 (SW monsoon period). For the same period, 10.7 cm radio flux proton fluence

100 Mev (protons $cm^{-2}$-day-sr) and electron fluence > 2 Mev (electrons $cm^{-2}$-day-sr) and sunspot numbers are collected from NOAA, Space Environment Center. The rainwater was analysed by PE - 138 water analyzer and *p*H, electrical conductivity was calculated and the relation was examined between electrical conductivity of rainwater over Pune and 10.7 cm Flux, proton/electron fluence and sunspot numbers. The plots of electrical conductivity of rainwater over Pune during June-July 2006 following proton, electron fluences and sunspot numbers have been shown in Figs 1-3.

## 3 Results and Discussion

The solar flares emit electron particles[8]. These electrons interact with Earth's magnetic field and atmosphere causing weather, geophysical and behavioural changes. These charged particles from the sun affect Earth's magnetic field and increases atmospheric nucleation which then affects cloud formation and thus the weather. It has been found that there is an increase in electron fluence > 2 MeV after BT > 7 and increase in temperature, ozone and precipitation[8]. The solar wind modulates the flow of current density (jz) in the global electrical circuit[6].

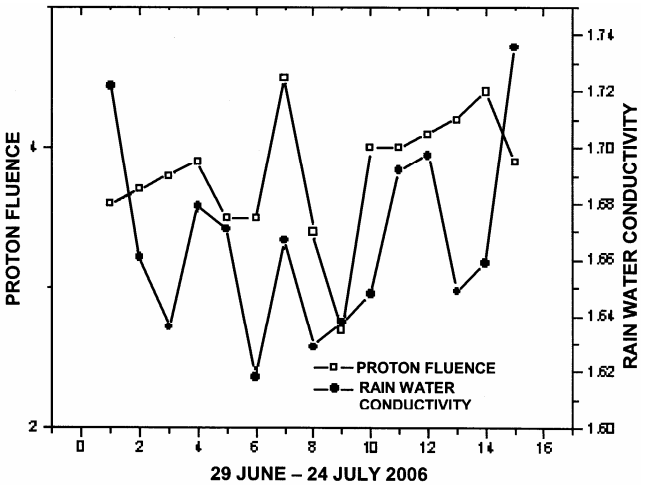


Fig. 1 — Electrical conductivity of rainwater over Pune during July 2006 following proton fluence

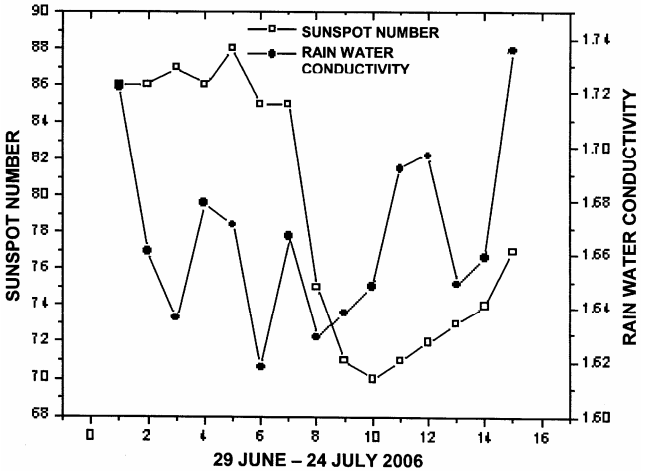


Fig. 2 — Electrical conductivity of rainwater over Pune during July 2006 following sunspot numbers

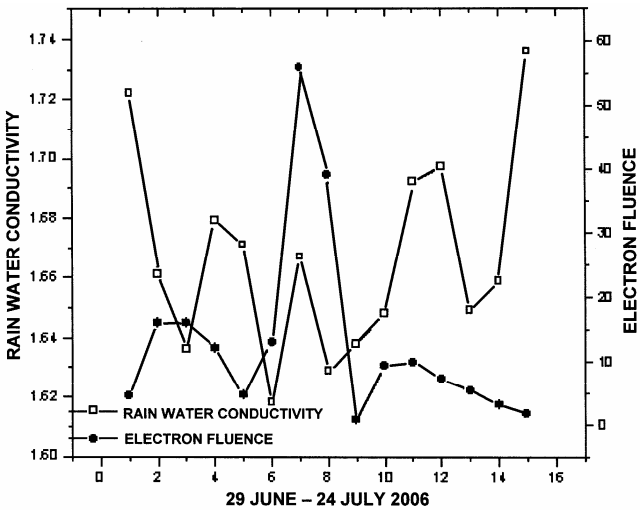


Fig. 3 — Electrical conductivity of rainwater over Pune during July 2006 following electron fluence

Table 1 — Proton fluences >100 MeV, electron fluences >2 MeV, *p*H and electrical conductivity of rainwater over Pune during 25 June - 23 July 2006

| Date | Proton fluence | Electron fluence | Electrical conductivity | *p*H |
|---|---|---|---|---|
| 25 June 2006 | 3.6e+03 | 6.6e+06 | 1.652 | 5.741 |
| 30 June 2006 | 3.7e+03 | 6.9e+06 | 1.722 | 5.656 |
| 2 July 2006 | 3.8e+03 | 1.8e+07 | 1.661 | 5.630 |
| 3 July 2006 | 3.9e+03 | 1.1e+07 | 1.636 | 5.433 |
| 4 July 2006 | 3.5e+03 | 2.9e+06 | 1.679 | 5.654 |
| 5 July 2006 | 3.5e+03 | 6.3e+06 | 1.671 | 5.709 |
| 6 July 2006 | 4.5e+03 | 2.1e+08 | 1.618 | 5.693 |
| 7 July 2006 | 3.8e+03 | 3.0e+08 | 1.667 | 5.598 |
| 10 July 2006 | 2.9e+03 | 9.5e+06 | 1.629 | 5.632 |
| 12 July 2006 | 2.9e+03 | 1.9e+06 | 1.638 | 5.650 |
| 14 July 2006 | 3.8e+03 | 5.3e+06 | 1.648 | 5.539 |
| 20 July 2006 | 4.1e+03 | 4.1e+06 | 1.692 | 5.402 |
| 21 July 2006 | 4.2e+03 | 2.7e+06 | 1.697 | 5.386 |
| 22 July 2006 | 4.4e+03 | 2.5e+06 | 1.649 | 5.269 |
| 23 July 2006 | 3.9e+03 | 2.7e+06 | 1.659 | 5.272 |

Table 2 — Correlation coefficients between proton fluence/electron fluence/10.7 cm flux, and electrical conductivity of rainwater (one lag) over Pune during 24 June - 23 July 2006

| | | |
|---|---|---|
| 1 | Correlation between10.7 cm flux and rainwater conductivity | 0.25 |
| 2 | Correlation between proton fluence and rainwater conductivity | 0.35 |
| 3 | Correlation between electron fluence and rainwater conductivity | 0.15 |

Solar variability modulates both the flux of incoming galactic cosmic radiation (GCR) received by the planets[1].

From the analysis, it is seen that one day after an increase in proton and electron fluences, rainwater electrical conductivity increases. Also it is observed from Table 1 that following an increase in proton fluence and electron fluence, *p*H in the rainwater decreases. It is seen from Table 2 that 10.7 cm flux electrical conductivity of rainwater over Pune are positively correlated.

## 4 Conclusions

Following an increase in proton and electron fluences, an increase in electrical conductivity and decrease in *p*H of rainwater of Pune is observed. This may be due to the change or intensification of charge due to strengthening of electro-scavenging effect.

## Acknowledgements

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