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A Study of Air Pollution Episode Over Delhi National Capital Region, India During October 29, 2016-November 03, 2016

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ABSTRACT

Northern India has an increase in surface air pressure during winter; this causes the atmosphere to clear out, resulting in the production of significant surface inversions. High-pressure zones are also calm and wind direction changes only when a western disturbance enters the area. The wind is substantially stronger when there is a low-pressure system. As a result, the pollutants in northern India are regulated by a sequence of high- and low-pressure weather situations. October 29, 2016, was when the wind direction unexpectedly shifted from NW to NE and then to N. Wind speeds dropped from 1-6 km/h to near-calm during this time, which indicated the passing of a high-pressure zone, based on the readings of the pressure gauges. Pollution from northern states was brought into the national capital region by a combination of low wind speed and the wind's direction. NCR was clogged with high levels of particulate matter during Diwali celebrations, which were exacerbated by heavy traffic, factory production, and firecrackers. The grave situation persisted until the wind shifted directions and increased its velocity. On the monostatic acoustic radar installed at REMTech, Shamli, detected the persistence of a substantially raised layer over the region, implying that vertical mixing of pollutants was severely harmed or limited. As a result of this state, pollutants accumulated, resulting in a severe bout of air pollution. The findings of this study details an incident of such air pollution happened over Delhi NCR.

Key words : *Acoustic Radar, Air pollution, PM 2.5, PM 10, Temperature.*

Introduction

Many urban cities in India including National Capital Territory (NCT) of Delhi are adversely affected by air pollution since 2010s. A number of factors like atmospheric circulation, topography, vehicular emissions, industrial activities, construction, open waste burning and local weather patterns lead to extreme air pollution episodes. Additionally dust storms, forest fires and post-harvest open field burning are major part of air pollution. Increased air pollution is a growing threat to public health further that leads to disease of respiratory and circulatory system (Ahmed *et al*., 2015; Tzanis *et al*., 2019).

Over northern India, in the winter season surface atmospheric pressure increases from south to north as part of the Siberian High. A ridge runs from central parts of the country to the east coast of south peninsula and there are two troughs, one along the west coast of peninsula and another from

Tenasserim coast to Assam (Rao and Srinivasan, 1969). Due to this high pressure, atmosphere is clear and winds are calm, leading to the formations of the strongest surface-based inversions over northern India (Rao and Srinivasan, 1969; Viswanadham and Pinaka Pani, 1994; Iyer and Nagar, 2011). However, western disturbances approaching from west to east lead to snowfall in higher peaks of Himalayas and rains over plains (Rao and Srinivasan, 1969). Thus, these disturbances add moisture in the atmosphere which becomes responsible for dense fog incidences/episodes causing disruptions in air, rail and road services due to poor visibility associated with dense fog. The visibility phenomenon is considerably influenced by the mass of aerosols (Tyagi *et al.*, 2016). In fact, during winter season, the farmers burn their crop residue or stubble to clear their fields and since the thermal inversions are present, air-pollution density gets severely enhanced (Iyer and Nagar, 2011; Jain *et al.*, 2014; Badrinath *et al.*, 2006). Jain *et al.*, (2014) have found that agricultural crop residue burning contribute towards the emission of greenhouse gases (CO_2, N_2O, CH_4), air pollutants (CO, NH_3, NOx, SO_2, NMHC, volatile organic compounds), particulates matter and smoke thereby posing threat to human health. Ambient air qualities during wheat and rice crop stubble burning episodes have been studied right in the heart of Punjab (Mittal *et al.*, 2009). Badrinath *et al.*, (2006) have shown enhancement of pollutants in the Indo-Gangetic plains due to agriculture crop residue burning using satellite data.

During the winter season, Diwali-a major festival of India is also celebrated wherein people clean and decorate their houses, distribute gifts and explode fire crackers. All such activities lead to sudden enhancement of pollutants to such a dangerous level that entire northern India chokes due to high pollution density in the atmosphere (Chauhan *et al.*, 2014; Srivastava *et al.*, 2014; Rao *et al.*, 2012; Nigam *et al.*, 2016; Gadi *et al.*, 2009; Gautam *et al.*, 2018; Gupta and Garg, 2018) and the health issues become extremely serious due to deteriorating air-quality.

One such incidence of extremely high air-pollution levels was observed during the October-November, 2016 when India celebrated its Diwali festivity on October 30, 2016. During this period, an acoustic radar was in operation at Shamli, India and on the basis of various other complimentary observations, author investigated the reasons and the atmospheric processes responsible for this air-pollution episode over northern India.

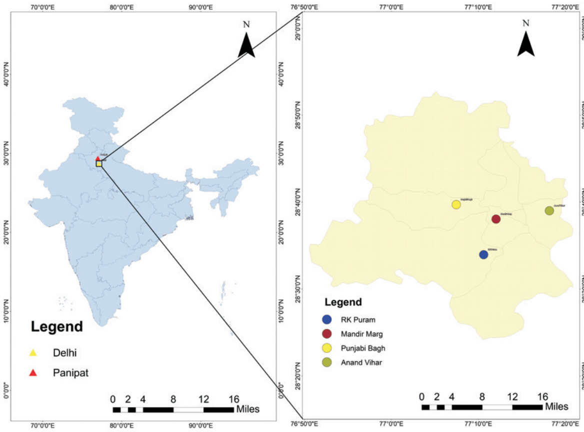


Fig. 1. Map showing study locations

Materials and Methods

Study Area

Study was conducted in Delhi, Panipat and Shamli to analyse the air quality during 29 October 2016 to 3 November, 2016. Selected study locations are shown in the map.

Air Quality Data for Delhi and Panipat

Delhi is located in North India at 28°242173 and 28°532003 N Lat., 77°452303 and 77°212303 E long and approximately 216 m amsl. Located in subtropical belt, Delhi has intensely hot summer and cold winters. A significant change in the air quality all over Delhi has been observed in the past few years. Therefore, Central Pollution Control Board installed air quality monitoring station in different parts of Delhi under National Ambient Air Quality Monitoring Programme. In the present study total four monitoring sites were identified in Delhi region to measure the air pollution levels, which includes Anand Vihar, Punjabi Bagh, R K Puram, and Mandi Marg. The daily data of air pollutants for PM2.5, PM10, NOx and SO_2 was obtained from CPCB website at the interval of every 30 minutes for the period of 20 October 2016 to 7 November 2016 and analyzed statistically to observe the air quality over NCR region. PM10 level were also measured for Panipat during the study period.

Acoustic Radar and data collection for Shamli

A monostatic acoustic radar has been designed, developed and installed in the campus of the Roorkee Engineering & Management Technology Institute, Shamli, India (Figure 1). It shows the hexagonal antenna cuff installed on an aesthetically created structure. It houses a 4′ parabolic antenna facing the sky and the system surrounding is shown in Figure 2. The acoustic radar was installed at such a location so that the sound noise caused by vehicular movement on the Panipat-Shamli highway was the minimum, it is required to have maximum S/N ratio of the received signals.

(a) (b)

Fig. 2. (a) Google map of the campus and the adjoining area (b) Acoustic radar installed in the campus of Roorkee Engineering & Management Technology Institute, Shamli, India.

Results and Discussion

Air Quality Analysis

The data for particulate matter and gaseous pollutants of Anand Vihar, Punjabi bagh, Mandir Marg and R K Puram was analysed and graphs plotted are presented in Figure 3 a and 3b. The overall air quality index over Delhi was found to be severe (426) on 30th October 2016. Disturbingly, PM 10 and PM 2.5 levels went very high in some parts of national capital during the study period. Anand vihar, one of the most polluted areas in national capital recorded high level of pollutants. Maximum PM2.5 value was observed to be 890 μg/m^3 during day time, i.e. 11:30 am to 12:00 pm while minimum PM 2.5 value was observed 7.53 μg/m^3 at 4:30 pm on 5 November 2016. PM 10 was in the range of 299 to 993.33 μg/m^3. Maximum value of 993.33 μg/m^3 was recorded on 30 October 2016 in morning while minimum of 299 μg/m^3 was recorded on 25 October 2016 during afternoon. The highest NOx concentration with maximum value of 495 ppb was observed in the morning on 31 October 2016 while SO_2 concentration reached maximum (199.86 μg/m^3) in afternoon on same day. The data collected from Mandir Marg recorded maximum PM 2.5 concentration of 985 μg/m^3 during morning hours on 31 October 2016 and maximum PM 10 (992 μg/m^3) on 5 November 2016 during evening hours. Maximum concentration of NOx was recorded to be 499.02 ppb on 29 October 2016 during night hours with an average value of 146.13 ppb during the study period. SO_2 concentration reached maximum 97.58 ug/m^3 on 31 October 2016 in morning at 10:00am and minimum 2.42 ug/m^3 on 5 November 2016 in evening.

Another study site selected to measure air pollutants concentration was R K Puram that also showed high concentration of pollutants. PM2.5 concentration on the site reached 976 μg/m^3 on 5 November 2016 in evening and found minimum (14 μg/m^3) on 21 October 2016 in evening. Concentration of PM 10 was recorded maximum (999.4 μg/m^3) on 31 October 2016 in morning and minimum of 88 μg/m^3 on 25 October 2016 in evening. Maximum values of NOx and SO_2 concentrations were recorded to be 496.65 ppb and 198.8 μg/m^3 and minimum 17.8 ppb and 0.02 μg/m^3 during study period. Air pollutants concentration recorded for Punjabi Bagh were also plotted to analyze the maximum and minimum concentrations. PM2.5 concentration reached maximum (900 μg/m^3) on 2 November 2016 in morning and PM 10 concentration was recorded maximum (999 μg/m^3) on 5 November 2016 in afternoon. In case of NOx and SO_2 maximum concentration were recorded 497.02 ppb on 29 October and 189.13 μg/m^3 on 31 October 2016. Graphs further indicate that almost similar or minor changes in air pollutants concentrations were recorded several times during study period.

Variation of PM2.5, Wind velocity and Wind Direction over Delhi during October 20, 2016 to November 10, 2016 showed that the PM2.5 values touched more than 1200g/μm3 between October 30-31, 2016 leading to an air-pollution episode in which so much of suffocation was felt that everyone was concern about the air-pollution and the relief from this incidence (Fig. 4).

To investigate the fire data, online data of PM10 from Panipat was plotted (Figure 5), it shows that air-pollution enhancement was not localized, it had spread over a large area over northern India. At Panipat, PM10 started increasing from October 29, 2016 and reached at its peak on November 3, 2016.

Further, it is seen that farmers from Punjab go for stubble burning during this period, leading to gen-

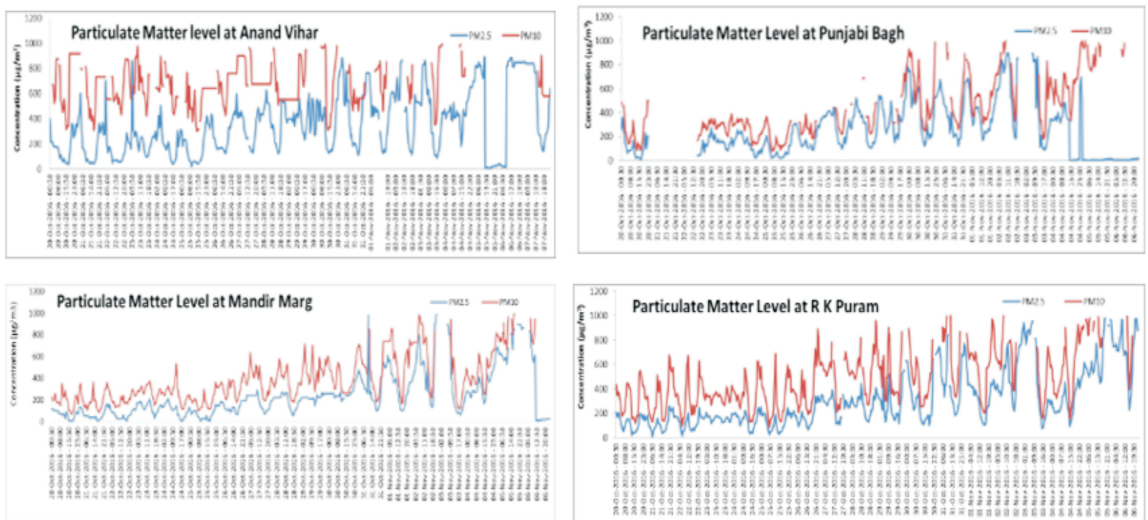


Fig. 3. (a) Particulate matter values for Anand Vihar, Punjabi Bagh, Mandir Marg and R.K. Puram during 20 October 2016 to 6 November 2016.

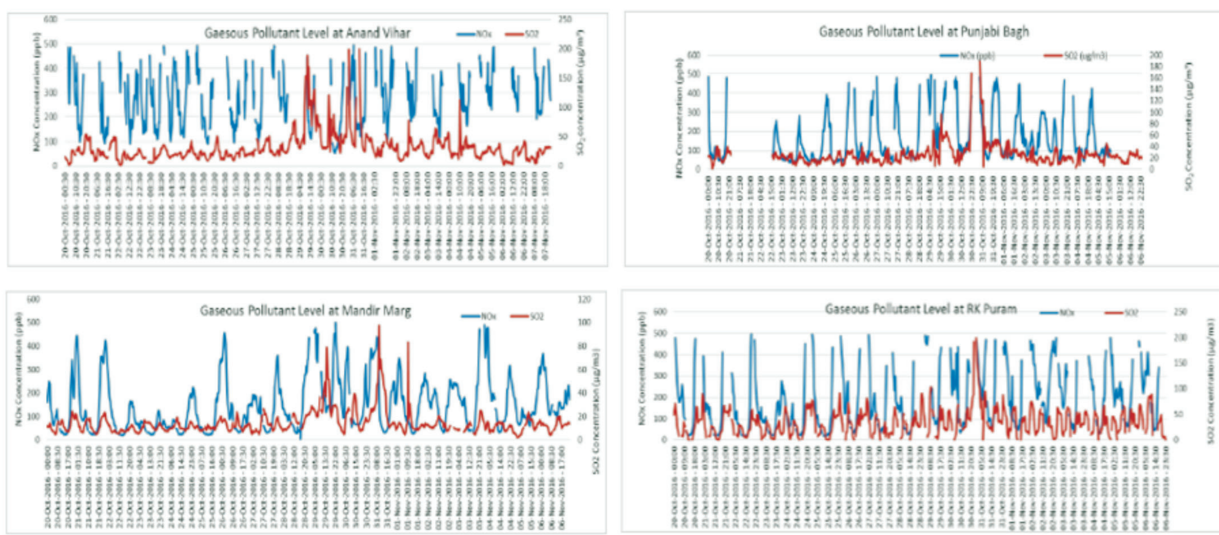


Fig. 3b. Gaseous pollutant values for Anand Vihar, Punjabi Bagh, Mandir Marg and R.K. Puram during 20 October 2016 to 6 November 2016

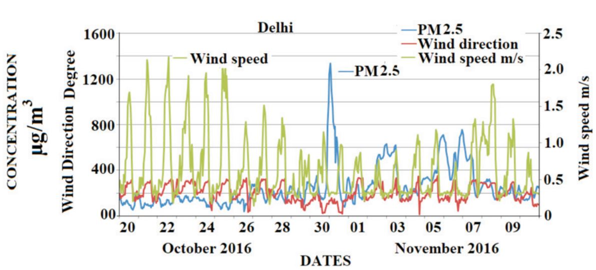


Fig. 4. Shows variation of PM 2.5 data during October-November, 2016.

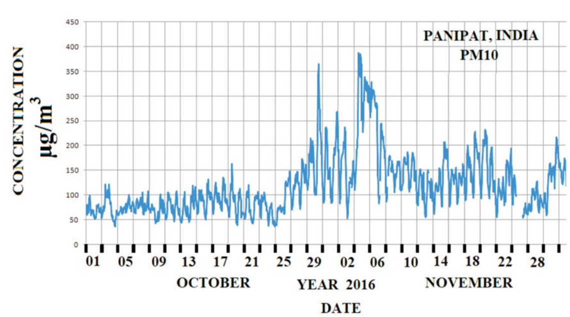
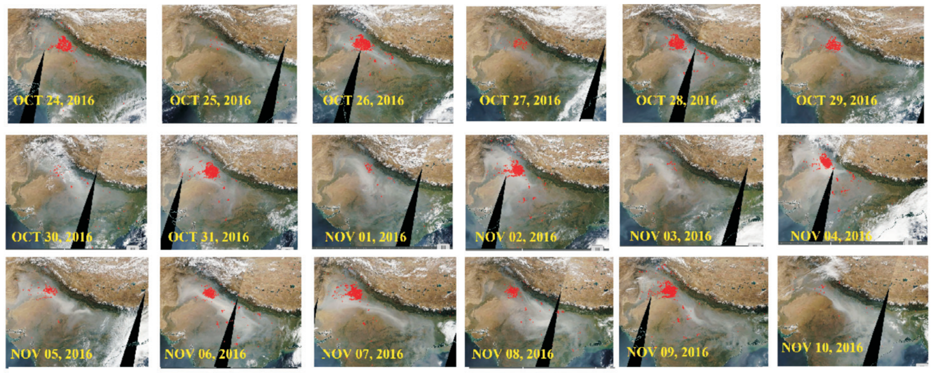


Fig. 5. Variation of PM10 over Panipat during air-pollution episode



Fires over Northern India https://worldview.earthdata.nasa.gov/

Fig. 6. The location of fires and the movement of air-pollution predominantly along the direction of the wind.

eration of air-pollution along the Gangatic plains. The pollution so caused moves along the direction of the wind and if surface-based inversions or elevated inversions are present, they lead to a serious situation. Figure 6 shows this burning over Punjab / Haryana and its resultant air-pollution density over the entire India. The air-pollution was flowing along the Himalayas in the SW direction between October 24-27, 2016. However, on October 28, 2016, its direction changed towards South and a thick cloud of smog covered Delhi (Capital of India) and the adjoining areas from November 01, 2016 onwards. The situation continued till November 06, 2016 and after that the pollutants started dispersing towards their usual SE direction. Similar studies done by Mittal *et al.,* (2009) and Tzanis *et al.,* (2019) also investigated the effect of crop residue burning in North India during October and November. In addition to Diwali festival, other sources such as crop residue burning, vehicular emissions, and dust from construction sites also Contribute to high level of particulate and gaseous air pollutants (Tzanis *et al.,* 2019).

Meterological Parameters

It is seen from the surface based meteorological parameters (Figure 7) that the wind speed was low and predominantly it was from the NE direction. It is this wind which inducted load from the northern India and coupled with the local load of Diwali festival, both resulted in the worst episode during October-November, 2016. Moreover, the atmospheric pressure was high, it means atmosphere was transparent, leading to the formation of inversions and low wind speeds.

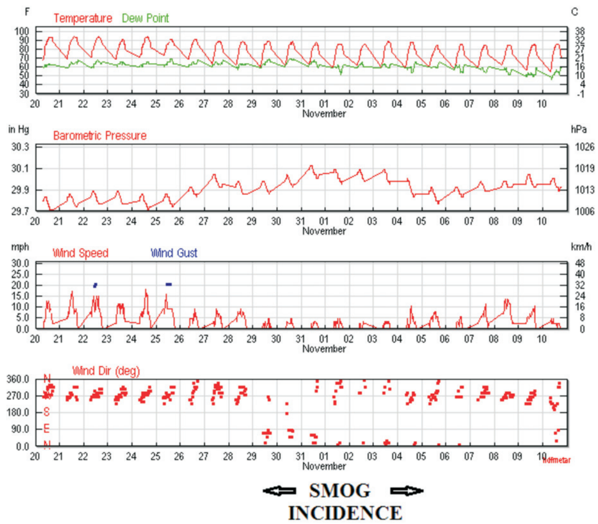


Fig. 7. Surface level parameters during the air-pollution episode over National Capital Region of India.

To investigate the presence of surface based inversions, data from the radiosonde from Delhi station (14282) has been analysed and it is seen from Figure 8 that a surface based inversion was present during the event. We can see surface based temperature lower than the temperature at 925mbar level.

To investigate the reason on the change of wind direction over India, wind data reported from Australia Meteorological Department and Plymouth State Weather Centre, Australia for the study period (October-November, 2016) was also explored. It shows that the winds over northern India was influenced by the presence of low pressure systems formed over the Bay of Bengal. On October 25, 2016, there was a low pressure zone marked as "L" persisting near Bangladesh. Due to this Low pressure

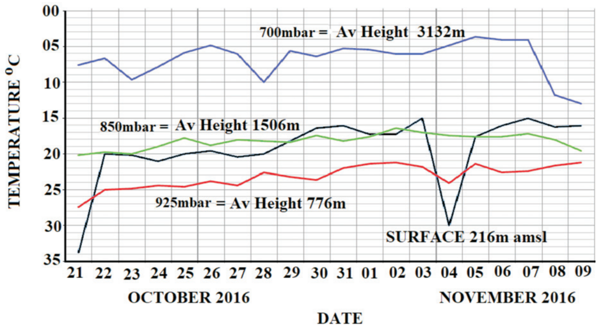


Fig. 8. Temperature at various lower levels computed from radiosonde data over Delhi shows that the surface air temperature was lower than the 925mbar level during the entire air-pollution episode. It is the presence of surface based inversion that helped in the build up and persistence of the event.

area, the movement of the wind was towards east. However, from the next day itself, till November 02, 2016, this low pressure area moved towards the southern tip of India and due to this movement, winds over northern India turned predominantly towards south. This turning of wind led to the transport of air pollution from northern states towards Delhi and since Diwali was on October 30, 2016, the local pollution coupled with high pressure area, low winds and stagnant atmospheric condition caused air-pollutions episode. Later on, another low pressure system developed and it moved towards Bangladesh side, that changed the wind direction along the Himalayas, thus clearing the accumulation of pollution over the national capital region (NCR), India. Acoustic radar observations at Shamli, India also indicated that the sunshine was dull due to air-pollution and even the strength of inversion was very weak during the study period (Fig. 9).

Conclusion

The concentration of particulate matter, gaseous air pollutants and adverse meteorological conditions shows the degradation of air quality over Delhi NCR during the study period. Emissions from transport and construction industries, episodic event like Burning of fire crackers during Diwali and winter inversion, are amongst the reasons for poor air quality while the major and biggest reason seems to be emissions released from burning of crop residue. Due to these usages many harmful gasses like Sulfur dioxide, Carbon dioxide, Carbon monoxide, Magnesium, Nitrogen dioxide, Phosphorous, Zinc and gasses due to Color dyes used for the crackers are released into the atmosphere. These released gasses mixed with air and effect human beings with many diseases. The Chemical emulsion used in the crackers will show its effect on our body parts. Also, people must realize that synoptic wind patterns govern wind speed and direction over India and in such cases, nothing can be done by any government. It is the responsibility of each and every citizen to minimize load of air-pollution in winter as dispersal is minimum and northern India acts as a bowl.

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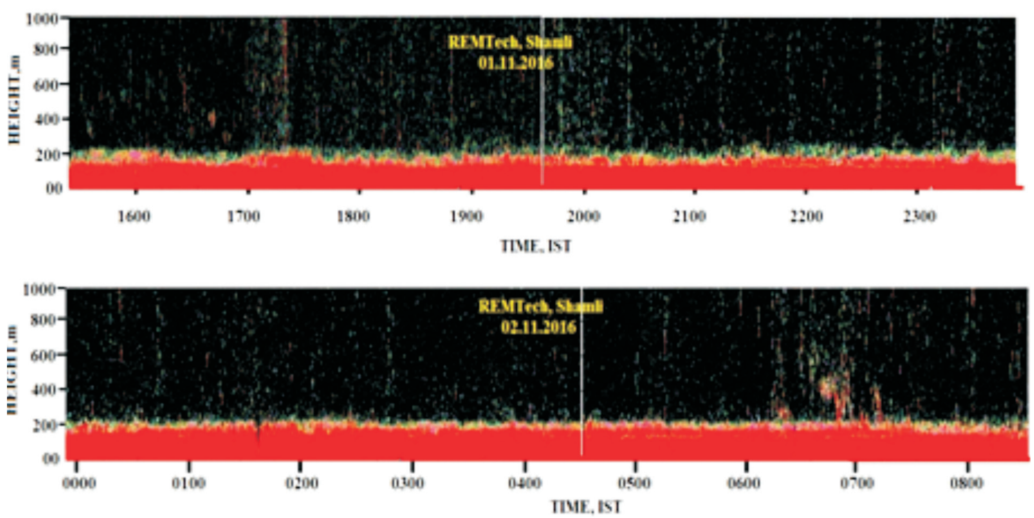

Fig. 9. Acoustic radar observations at Shamli

to allow installation of Acoustic Radar in the campus, Central Pollution Control Board Website, IMD Website, Australia Meteorological Department and Plymouth State Weather Centre, Australia's website from where data was collected to carry out this research study.

References

Ahmed, S., Siddiqui, W.A. and Maji, S. 2015. Air quality assessment and its relation to potential health impacts in Delhi, India. *Current Science*. 109(5): 902-909.

Badarinath, K.V.S., Kiran Chand, T.R. and Krishna Prasad, V. 2006. Agriculture Crop Residue Burning In The Indo-Gangetic Plains: A Study Using IRS-P6 Awifs Satellite Data. *Current Science.* 91 : 1085-1089.

Chauhan, V.S., Singh, B., Ganesh, S. and Zaidi, J. 2014. Status of Air Pollution during Festival of Lights (Diwali) in Jhansi, Budelkhand Region, India. *Asian Journal of Science and Technology.* 5 : 187-191.

Gadi, R., Mandal, T.K., Dixit, C.K., Singh, K., Saud, T., Singh, N. and Gupta, P.K. 2009. Study of Temporal Variation in Ambient Air Quality during Diwali Festival in India. *Journal of Environmental Monitoring & Assessment*. 169 : 1-13.

Garg, A. and Gupta,, N.C. 2018. Episodic levels of PM_{10}, $PM_{2.5}$ and PM_1 during Diwali: A study in urban areas of Delhi. *International Research Journal of Environmental Sciences*. 7(3): 25-30.

Gautam, S., Yadav, A., Pillarisetti, A., Smith, K. and Arora, N. 2018. Short-Term Introduction of Air Pollutants from Fireworks During Diwali in Rural Palwal, Haryana, India: A Case Study. *IOP Conf. Series: Earth and Environmental Science*. 120.

Iyer, U. S. and Nagar, S.G. 2011. Variability in surface inversion characteristics over India in winter during the recent decades. *J. Earth Syst. Sci.* 120(1): 73–84.

Jain, N., Bhatia, A. and Pathak, H. 2014. Emission of Air Pollutants from Crop Residue Burning in India. *Aerosol and Air Quality Research*. 14: 422-430.

Mittal, S.K., Susheel, K., Singh, N., Agarwal, R., Awasthi, A. and Gupta, P.K. 2009. Ambient Air Quality during Wheat and Rice Crop Stubble Burning Episodes in Patiala. *Atmos. Environ.* 43: 238–244.

Nigam, S., Kumar, N., Mandal, N.K., Padma, B. and Rao, S. 2016. Real Time Ambient Air Quality Status during Diwali Festival in Central, India. *Journal of Geoscience and Environment Protection*. 4: 162-172.

Rao, Y.P. and Srinivasan, V. 1969. Forecasting Manual: Part III: Discussion of typical synoptic weather situation-I-I: Winter western disturbances and their associated features, India Meteorological Department, FMU. Rep. No. III-1-1, The Deputy Director General of Observatories (Forecasting) Poona-5: 1-131.

Rao, S.P., Gajghate, D.G., Gavane, A.G., Suryawanshi, P., Chauhan, C., Mishra, S., Gupta, N., Rao, C.V.C. and Wate, S.R. 2012. Air Quality Status during Diwali Festival of India: A Case Study. *Bulletin of Environmental Contamination and Toxicology*. 89(2): 376-379.

Srivastava, R.K., Sagar, K. and Beig, G. 2014. Measurement of Particulate Pollution in Jabalpur City during Diwali Festival. *International Journal of Environmental Science & Toxicology*. 2: 136-142.

Tyagi, S., Tiwalr, S. and Mishra, A. 2016. Impact of air pollution on visibility over New Dlhi, India: A case study of winter fog. *Int. J. Adv. Sci. Eng. Tech.* 4(4): 215-218.

Tzanis, C.G., Ganguly, N.D., Philippopoulos, K. and Deligiorgi, D. 2019. Analysis of a severe air pollution episode in India during Diwali festival – a nationwide approach. *Atmosfera*. 32(3): 225-236.

Viswanadham, D.V. and Pinaka Pani, V.V.S.N. 1994. Atmospheric dispersal capacity over North India. *Theoretical and Applied Climatology*. 48(4): 179-185.