Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Spl Issue [5] 2022 : 73-77

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD

ORIGINAL ARTICLE **OPEN ACCESS**

Assessment of COVID-19 Lockdown Effects on Atmospheric Aerosol Properties Over Rohtak, Haryana, India

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ABSTRACT
Globally, the COVID-19 pandemic has caused a severe threat to human life and a complete lockdown was declared in India as a preventive measure. In the present study, aerosol optical properties over Rohtak an urban area in North-Western India were studied from February 24, 2020 to April 20, 2020 to assess the effect of COVID-19 Lockdown on atmospheric aerosol load and optical properties. The lockdown period showed about 30% decrease in AOD, compared to the pre-lockdown period. During the lockdown, there is also a reduction in the angstrom exponent and SSA values. Lower values of the angstrom exponent suggest the dominance of coarse-mode aerosols. The volume-size distribution also showed a reduction in fine-mode aerosol and an increase in coarse-mode aerosol during the lockdown. The study shows that anthropogenic aerosol load significantly decreased during the lockdown. Therefore, in the future government may use lockdowns as a potential solution to control air pollution in urban pollution hotspot areas.
KEYWORDS:*AOD, SSA, Asymmetry parameters, Volume-size distribution*

Received 22.10.2022 Revised 23.11.2022 Accepted 18.12.2022

INTRODUCTION

The world has faced a highly contagious COVID-19, which was first reported in Wuhan in December 2019 [6, 4]. Covid-19 is a highly transmissible disease and due to its global infection, World Health Organization (WHO) has declared it a pandemic. Globally, more than 10 million confirmed cases and more than 500000 deaths were reported within a short span of time as of 30th June, 2020(https://www.worldometers.info/coronavirus/) [1]. India is facing more challenges due to COVID-19 because of its high population density. India is 2nd most populated country in the world, with a population of 1.38 billion [9-16].

Therefore, to contain the spread of COVID-19, the Government of India has declared a 21 days complete lockdown in the country from March 24, 2020 midnight to April 14, 2020. This was further extended up to May 3, 2020, followed by the third and fourth phases untilMay 31, 2020.

Lockdown resulted in the shutdown of most of power and industry, mining, transport, hotel, restaurants, tourisms, construction works, markets and shopping malls except the essential services. As a result, significant reduction was observed in the air pollution level [21] especially in the particulate matter and atmospheric aerosol concentration.In India several studies have shown reduction in the air pollution due to lockdown [18-24]. Kanniah et al. [8] have reported a notable reduction in AOD over South East Asia region in Singapore, Malaysia, Philippines. In Malaysia about 40% reduction in AOD was observed during March-April 2020 as compared to the same period in 2019.

Atmospheric aerosol perturbs the climatic system, earth's radiation budget and cloud formation by absorbing and scattering the incoming and outgoing radiation [10-17]. Therefore, studying aerosol is crucial to understanding their contribution to global warming and climate change. The present study was intended to examine the variation in the aerosol's concentration and properties due to lockdown over Rohtak, India. In urban areas the anthropogenic activities associated with transportation and industrial processes are the major sources of atmospheric aerosols [1-7]. These activities have been shutdown due to complete lockdown, therefore the study of the degree of change in the aerosol concentration and properties is really important to understand the impact of anthropogenic activities on atmosphere and air quality. In this study aerosol properties such as aerosol optical depth (AOD), angstrom exponent (α), single scattering albedo (SSA), asymmetry parameters (ASY), volume-size distribution and Aerosol Radiative forcing (ARF) are analyzed.

STUDY SITE, INSTRUMENTATION AND METHODOLOGY

Rohtak is an urban in the northwest part of Indo Gangetic plane between latitude 28.89°N and longitude 76.58°E. It is situated about 70 km northwest of Delhi. Rohtak has a population of about 0.37 million (as per the census 2011) and due to its proximity to national capital, it has shown rapid increase in industrialization and vehicle population.

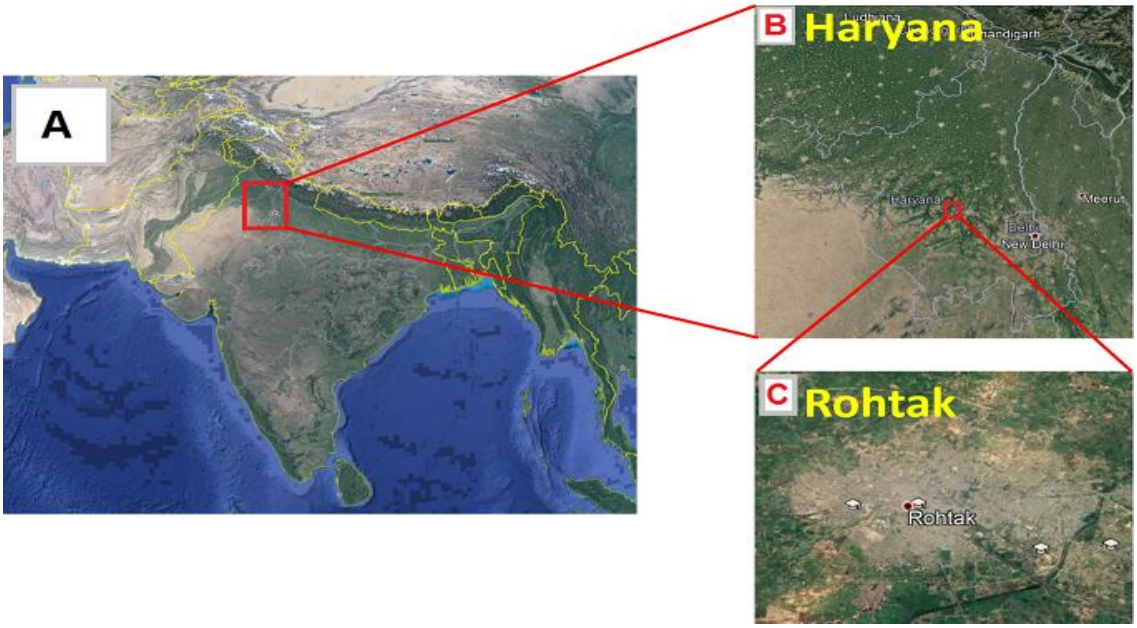

Figure: 1 Overview of the study site taken by Google Earth.

Aerosol data was collected by Prede POM-02 Sun/sky radiometer installed in the premises of Maharshi Dayanand University Rohtak, which is a part of the Skynet-India network of the Indian Meteorological Department New Delhi. This instrument measure direct and diffuse radiation in the spectral range from 340-2200 nm at eleven predefined scattering angles (315, 340, 380, 400, 500, 675, 870, 940, 1020, 1600 and 2200 nm). For this study aerosol optical properties are retrieved at 340, 380, 400, 500, 675, 870 and 1020nm. Aerosol properties such as AOD, Angstrom exponent, SSA, refractive index and volume-size distribution have been retrieved by SKYRAD.pack software (V4.2) [12]. In-situ calibration constant in the sky radiometer software pack was calculated by Improved Langley plot method [5]. The precision of the in-situ calibration of the sun-skyradiometer has been estimated to be within 1-2.5%, depending on the wavelength. The detailed description of calibration of POM-02 sun/sky-radiometer can be found elsewhere [16].

In this study, data from February 24, 2020 to April 20, 2020 was used. The period from February 24, 2020 to March 23, 2020 is considered as before lockdown while from March 24, 2020 to April 20, 2020 is considered as during lockdown period.

RESULTS AND DISCUSSION

CHANGES IN DAILY MEAN AOD 500NM

AOD is one of the major parameters to assess the effects of aerosol on climate because it represents the total attenuation of incoming solar radiation. Therefore, to quantify the effects of lockdown on AOD, the difference between the pre-lockdown and during-lockdown period was studied and time series plot for the daily average AOD 500 nm is illustrated in figure 2a. This showsthe mean value of AOD before lockdown was 1.08 while during lockdown that reduced to 0.90. The observed decrease in AOD was 18% during lockdown period as compared to before lockdown. Similar results of decrease in aerosol load were also observed over other Indian regions [19-26]. This significant decreasein the aerosol load isclearly associated with the reduction in the anthropogenic emission due to shutdown of most of the activities. Therefore, transportation, industrial activities, biomass burning can be considered as major contributor of aerosol load.

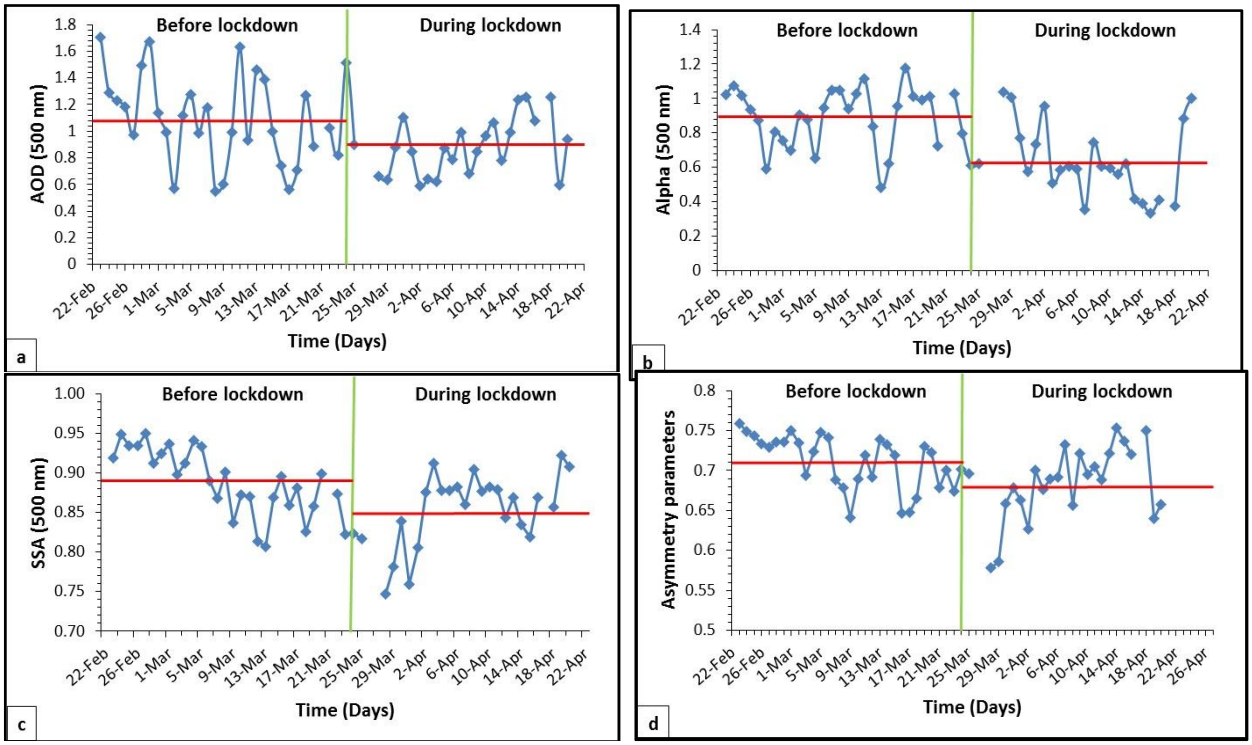

Figure: 2 Variability in daily mean (a) AOD 500 nm, (b) α 500 nm, (c) SSA 500 nm and (d) ASY (500 nm) (In graphs, mean value is shown with red line).

CHANGES IN DAILY MEAN ANGSTROM EXPONENT (A)

Figure 2b depicts the mean value of the angstrom exponent before and during the lockdown period. The mean value of the angstrom exponent reduced from 0.89 before lockdown to 0.63 during the lockdown. This is a significant decreased of about 30%. This clearly indicates the decrease in the fine mode particles.Similar trends of decreasing angstrom exponent due to lockdown was reported by Shukla et al. [22] over Kanpur and Yadav et al. [27] over Indo-Gangetic plain. It also suggests that anthropogenic activities such as vehicular pollution, industries and biomass burring are major contributors of fine mode aerosol. Therefore, due to restrictions on these activities, the concentration of fine particles decreased during the lockdown period.

CHANGES IN DAILY MEAN (SSA)

Figure 2c depicts the mean SSA value before and during the lockdown period. The average value of SSA before lockdown and during lockdown are 0.89 and 0.85, respectively. This observed change of about 5% indicates the slightly higher concentration of absorbing aerosolsthan scattering type aerosol such as dust. This may be attributed to the lesser concentration of road side dust due to restrictions in vehicular activities during the locdown period. Sarla et al. [25] has also reported the decrease in SSA during lockdown period over Indo-Gangetic Plain. In another study similar trend of decrease in SSA was observed during lockdown period, over Wuhan, China [28].

ASYMMETRY PARAMETERS (ASY)

ASY gives information about the angular distribution of the scattering of solar radiation by aerosols. Values of ASY ranged from −1 (for entirely backscattered light) to +1 (for entirely forward scattered light) and it depends on composition and distribution of aerosol [23]. Variability in daily mean values of asymmetry parameter is depicted in figure 2d.ASY values ranged between 0.76-0.58 which clearly suggesting the very high variability in the particles size. The similar results of higher variability were reported in previous studies also [1, 2, 18]. Higher value of asymmetry parameter suggesting more scattering in forward direction.

VOLUME/SIZE DISTRIBUTION

Figure 3 shows the value of volume size distribution before lockdown and during lockdown period. Generally bimodal distribution of particles was observed over northern India with dominance of coarse mode aerosol [17]. During the lockdown period, a slightly higher volume of coarse particles may be associated with an increase in the agricultural activities because April is the harvesting period of wheat in North-Western India. Another factor which can affect the volume-size distribution during pre-monsoon period is dust storms [3, 17, 20]. During the lockdown, sharp decrease in fine mode particles (0.1-1.0 μm)

was observed. This clearly showing the effects of decrease in anthropogenic activities. Several other studies have also shown the relation between anthropogenic activities and fine mode aerosols [13, 8, 9].

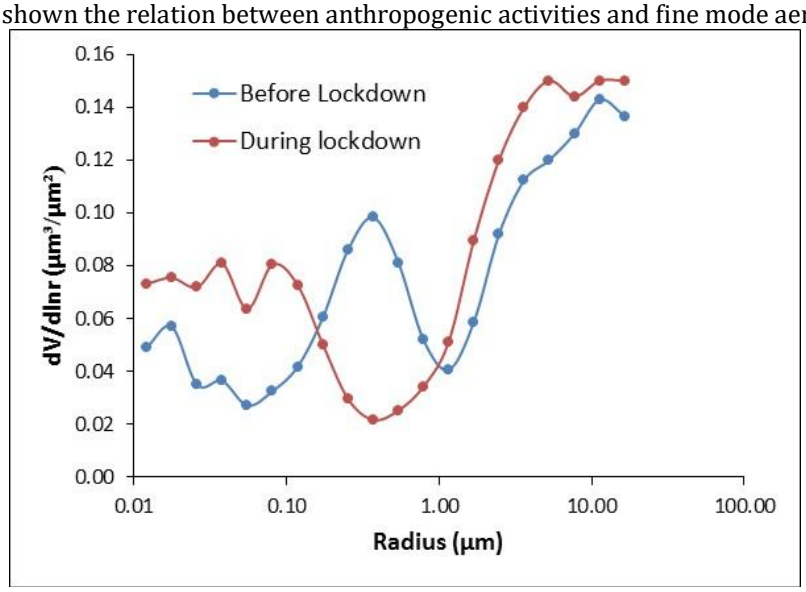

Figure: 3 Average aerosol volume-size distribution.

CONCLUSION

The present work aims to study the effects of lockdown on atmospheric aerosols over Rohtak, an urban area in North-Western India. During the lockdown period significant decrease in the AOD upto 30% was observed as compared to pre-lockdown periodwhich indicates that anthropogenic activities are the major contributors of aerosols in the urban area. Average values of SSA and Angstrom exponent at 500 nm have also shown a decrease during lockdown. There is also observed a sharp decrease in fine mode particles with radius 0.1-1.0 µm which attributed to decrease in fuel burning and other anthropogenic activities.

ACKNOWLEDGEMENT

The author is very thankful to Vice-Chancellor SGT University and Director General of Meteorology, India Meteorological Department for encouragement and providing all the facilities to carry out this research work.

GRANT SUPPORT DETAILS

The present research did not receive any financial support.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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CITATION OF THIS ARTICLE

Vikram Mor, M. Sateesh: Assessment of COVID-19 Lockdown Effects on Atmospheric Aerosol Properties Over Rohtak, Haryana, India. Bull. Env.Pharmacol. Life Sci., Spl Issue [5]: 2022: 73-77.