MONITORING OF THE AIR QUALITY IN ALIGARH CITY, INDIA USING SPOT : VGT DATA

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ABSTRACT

The temporal and spatial characteristic of Atmospheric Optical Depth (AOD) is monitored over the Aligarh city in Doab region of Ganga and Yamuna (India). It is indicated from the AOD results that Southern parts of the city’s atmosphere has higher AOD and lower AOD in the North of city. The field based studies conferred the direct relationship with dust deposition rate and AOD in the study area. The highest AOD and highest rate of dust deposition lies in the southern part of city. However, lowest AOD and rate of dust deposition lies in the North of city. The work was performed and analysed during the period Nov 1998- July 1999. Temporal variation in AOD also indicated lowest value in month of March and highest in the month of June. The higher value of AOD in winter period (December) is related to earlier drier months in (October –December). The decrease in AOD during January –March is caused by winter showers in most of the city area. Highest AOD in June is due to mass dust transfer along with loo winds coming from Western Rajasthan. Nature of the temporal variation shows spatial dissimilarity i.e., highest AOD in the North of the city is observed in June, while in the Southern most of the city it is observed in July. The present study provides an option to monitor air quality in the city atmosphere.

Key Words: AOD (Atmospheric Optical Depth), Air pollution, Aerosols, Aligarh, Remote sensing techniques

INTRODUCTION

Aerosols are solid particles and remain suspended in the atmosphere at various sizes from \(10^{-3}\)mm to \(10^{-6}\)nm.\(^1\) These particles are the major cause for unpleasant air quality in Indian cities. High concentration of aerosols in these cities is primarily due large availability of aerosols in the environment. The generation of this dust is primarily due to large variation in diurnal temperature which causes high rate of physical weathering of natural material and contribute to higher concentration of aerosols. Along with natural source of the dust, the anthropogenic activity i.e., automobile emission, construction activity, and other industries like cement industry, mining industry are also major sources of aerosols in the city atmosphere. The larger size particle are filtered through the respiration track, but the finer particle i.e., PM10, PM 5 and PM 2.5 reaches to the lungs and cause various physiological disorder related to respiration in living organisms. Ultra fine particles, which are less than 1.0nm in diameter have high potential to penetrate deeply into the respiratory tract causing inflammation and irritation.\(^2\) Aerosols concentration in the atmosphere also impact on earth radiation budget and subsequently the climate change and offset the impact of increased concentration of green house gases.\(^3 \text{-} 10\)

Monitoring of these particles is a major challenge because it require on spot monitoring of the air through high volume sampler and Anderson samplers. Results of the field based monitoring provide site specific characteristics of aerosols concentration and size distribution. An alternative of aerosols nature and concentration can be determined through analysis of interaction of the EMR (Electro Magnetic Radiation) with aerosols. The dust turbidity as measurement of aerosols concentration in atmosphere can be measured through Atmosphere Optical Depth. Numerous
results have been obtained through these experiments and suggest that the (AOD) Atmospheric Optical Depth is closely related to aerosols, concentration and nature of particles in the atmosphere.\textsuperscript{11}

Numerous techniques can be used to extract Atmospheric Optical Depth, but priority should given to the easiest, fastest and low cost method. Hence, remote sensing is the best option with the advance technologies. Determination of AOD through remote sensing was developed by a single wavelength and single angle of observation.\textsuperscript{12} These observations are sensitive to ultraviolet light and discovered excellent observation for elevated smoke or dust layers above scattering atmosphere observations. The AOD determined through availability of the multi-temporal images at fix place at various wavelength of the EMR in various researches.\textsuperscript{13} The AOD is being obtained using AVHRR images (Advanced Very High Resolution Radiometer) over the ocean and land areas since last two decade.\textsuperscript{14,15} However, the regular monitoring of the AOD over the Land area is not easy because of the varying reflectance of the land area with seasons. The new opportunities are available to monitor the Earth Surface with high spectral, temporal and spatial resolutions along with better computing algorithm. It provided the opportunity to monitor the AOD over urban area easily because the reflectance in urban areas constants through in all seasons for selected wave length of EMR (Electro Magnetic Radiation). Based on this assumption the AOD are obtained using various remote sensing data over the urban areas. The studies have shown that the AOD of the EMR for 400–600nm are closely related to the concentration of PM10 in the city atmosphere. The spatial and temporal characteristic of the AOD were studied during the period of Nov 1998-July 1999 and it showed good correlation with PM10 concentration in the city atmosphere and prevalent climatic conditions. In recent years the global aerosols product is released based on MODIS data and available since 1999 with 10 x 10Km spatial resolution. The spatial and temporal characteristic of MODIS based AOD has been studied over Indian continent.\textsuperscript{16-19} The results indicated that the high loading of the aerosols particles of various sizes over Indian continent’s atmosphere caused decreasing in plant productivity. These results also can be utilized for urban quality monitoring and subsequently for environmental planning. Hence, present study is conducted to evaluate the AOD in North Indian middle size city for air quality monitoring. These cities represent a major part of the world population and need proper environmental planning. In this study a middle size urban area is chosen in the middle of the Ganga – Yamuna Doab and few hundreds km from Thar Desert in Rajasthan. In present study Spot Vgt data and remote sensing techniques are used in determining the Atmospheric Optical Depth (AOD) over the Aligarh city in Ganga basin.

\textbf{Area of study}

The city is located in the plains between the Ganga and Yamuna Rivers (Fig. 1). It is nearly a level plain and slight elevation in the centre. Southern part of the city has old habitation and new urbanization is taking place all along the busy National Highways. The Northern part of the city has less habitation and currently going under new urban developmental activity.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig1.png}
\caption{Location map of the study area (Aligarh city) \textit{Source : www.googlemap.com}}
\end{figure}

The Aligarh Muslim University, the prominent part of the city was once on the Northern edge of the city, now it is surrounded by new urbanization and now totally in middle of the city.\textsuperscript{20} Upper Ganga canal passes through in the North part of the city, while the southern part of the city has low lying area of the canal and this area is largely affected by saline soil. In the South eastern direction the famous tourist cities Mathura and Agra are situated. Busy Delhi –Kanpur and other highway (Aligarh
Climate

The area is located on the fringe area of the arid zone (Rajasthan) and fall under the semi arid climatic conditions. Climate in the area can be marked with distinct five seasons winter, spring, summer, monsoon and autumn. The winter prevail for three month (December – February) during the time, area is under influence of western disturbances and receive winter showers and foggy conditions prevails in the December and January. The spring season prevails hardly for two months (March –April) with moderate dryness and temperatures. The summer prevails for about three months (May – June) with high dryness and strong hot winds from South Western direction from Arid land in Rajasthan. These winds bring dust and caused to high dust concentration in June - July. Monsoon season (July – September) in the area is characterized by high humidity and rainfall. Autumn season (October to November) in the area commence after retreat of monsoon. In one climatic year the atmosphere events show high concentration of dust in the June and foggy conditions in December and January.

MATERIAL AND METHODS

The AOD over the urban area of Aligarh is determined through DTA (Digital Texture Analysis) method developed.\(^1\)\(^2\)\(^3\) In present study the AOD is determined for the ultra-violet spectrum of EMR associated with Spot Vgt B0 data. This range of EMR is most sensitive to PM10 and PM5 particles.\(^1\)\(^2\)\(^3\) In this study the weekly composite Spot vgt data is used, it has 1km spatial resolution and 1 day temporal resolution. The B0 weekly composite data is based on synthesis of maximum NDVI observed in last seven days and has minimum cloud contamination. Weekly Spot Vgt data was downloaded from website (Spot Vgt Web page) for first week of each month (November, December 1998 and January, February, March, April, May, June, July 1999). The data for monsoon months is excluded from the study because of higher probability of cloud contamination in atmospheric data.

The B0 band data of each week is subjected to geometrical projection (Latitude and Longitude) and Ellipsoids system (WS 86) and pixel values were converted to radiance. The Standard Deviation of each image is determined with window of 3 x 3 pixel using Geomatica 9.1.0. For determining the AOD, the November image is used as reference DTA image based on climatic characteristics. The AOD for each month is created based on ratio of Standard deviation of clearest image / Standard Deviation of interested image. This process is repeated and AOD image of each month is created. The contours of AOD for each month were plotted based on pixel values and analyzed.

RESULTS AND DISCUSSION

The average AOD, based on observed data for the November 1998– July 1999 month is illustrated in Fig. 2. It shows that the average AOD in the study area is 1.08 ranging (0.01 - 5) with high standard deviation of 0.765. The frequency analysis suggests that 60% of the area has AOD ranging (0.0 – 1.0), only 10% of the area shows AOD ranging (1.5 -2.0) and AOD more than 2 values covers only 5% area of study. Spatial variation in averaged AOD indicates that the atmosphere over Southern portion of the city represent high AOD. The high AOD areas are concentrated over the Southern part of urban areas and along the highways and Railways. However, the Northern portion of city’s atmosphere has low AOD.

![Fig. 2 : Spatial variation in average AOD (Atmospheric Optical Depth) in Aligarh city based on AOD of the December – July](image-url)
It is also observed that all the higher values of AOD are located in central southern portion of the study area. The observed AOD spatial variation conferred with the results obtained by field based measurement. The field survey indicated that the maximum rate of dust deposition was 38.8 gm/m²/month at the Delhi - Kanpur highway on Southern central part, minimum rate of dust deposition was 24.5 gm/m²/month at the AnoopShahar roadside in Northern part of the city. Spatial variation in AOD identify the sources of aerosols in atmosphere of the city. The high aerosols concentration in urban areas is due to automobile movement, house hold activity, industrial and constructional activity. On the high ways the high speed heavy automobile always destabilize the atmosphere and do not allow the settling of the aerosols. Hence, dust and other particles always accumulated in the atmosphere over these areas. Apart from anthropogenic causes the natural source of dust also play a major role in aerosols concentration in arid and semi arid region. In summer period of June the hot dry wind carry the dust from western Rajasthan and influence the air quality of the study area.

The temporal changes in AOD for the periods of December to June are shown in Fig. 3. It is observed that the higher AOD in December over the city atmosphere is due to preceding drier months (September - December). In the January the AOD decreases continuously till April and suddenly high AOD in the month of June and further decreases in the July.

![Temporal variation in AOD](image)

**Fig. 3**: Temporal variation of average AOD of atmosphere over Aligarh city

The sudden high AOD in month of June is result of hot winds from the southeastern direction of Rajasthan. However, the decrease in AOD in July is due to early monsoon or local shower in the form of Aandhi, which subside the aerosols due to Precipitation. While, higher value of AOD in December is probably due to preceding drier months which contribute to higher concentration of aerosols. The decreasing of AOD in January is related to scavenging of the aerosols by winter showers in January and February. Nature of the temporal variation changes with spatial characteristics i.e., highest AOD in the north of the city is observed in June and further decrease in the July irrespective of the area characterized by higher or lower average AOD. While in the Southern most of the city it is observed that highest AOD is observed in the July.

The temporal variations in distribution pattern of various classes of AOD along with areal coverage are shown in Fig. 4. It is observed that the temporal change in the area covering with AOD values ranging (1.0 -1.5) does not change significantly. The area covering with AOD ranging (1-2) increases consistently. Maximum change is observed for the area with low AOD values ranging (0.0 - 1. 0). Temporal variations in higher classes of AOD indicate that the large area is under influence of very high AOD in the month June.
It suggests that the area had lower AOD is replaced by high AOD due to dusty wind in month of June. Present study indicated that AOD for the Spt -Vgt, B0 data is sensitive to spatial and temporal variation in atmosphere quality over the Aligarh city. Hence, AOD observed from the space provides an option to monitor air quality in the city atmosphere with limited resources. The spatial and temporal characteristics of AOD map can be use for Air quality management in Environmental Plan of the city. Some of the measure can be arrange for safe atmosphere quality of the city i.e., covering of the open space, planting of the grass on open space, sprinking of the water on major busy road in summer time, relocating of the environmental sensitive population at safe place (School, Hospital), alternative roads for the heavy trucks and planting of the mature trees along highways, limitation of the automobile on certain roads and locations.

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