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Variation of aerosols in relation to some meteorological parameters

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सार - नवंबर 1998 से अगस्त 1999 के दौरान रूड़की में (29° 52' उ., 77° 53' पू. और एच.एम.एस.एल. 275 एम.) धरातल से 9 मीटर की ऊँचाई पर वायुमंडलीय ऐरोसॉल सांद्रता को मापा गया है। रूड़की में अप्रैल-जुलाई, 1999 की अवधि में सापेक्षिक आर्द्रता, तापमान, वर्षा और पवन गति जैसे कुछ मौसम विज्ञान प्राचलों को ध्यान में रखकर ऐरोसॉल की भिन्नताओं का अध्ययन किया गया है। ये प्रकाशिक निपात काऊंटर की सहायता से मापे गए हैं। यह काऊंटर 0.3 से 5.0 माइक्रोमीटर के आकार रेंज में ऐरोसॉल की सांद्रता की संख्या का मानीटरन करता है। यह माप क्रम प्रमुख्तः वायुमंडल में प्रकाशिक प्रभावों और विकिरण की प्रक्रियाओं के लिए उत्तरदायी है। प्रबल मौसम विज्ञान की स्थितियों के कारण बृहत्त आकार रेंजों (1.0 - 2.0 माइक्रोमीटर और 2.0 - 5.0 माइक्रोमीटर) में ऐरोसॉल सांद्रता की जून माह में अधिकतम तथा जुलाई के दौरान न्यूनतम प्रवृति पाई गई है। इसके अतिरिक्त जुलाई माह के अंत तक समान रूप से बनते हुए लघु आकार रेंजों 0.3 - 0.5 माइक्रोमीटर और 0.5 - 1.0 माइक्रोमीटर) में ऐरोसॉल की सांद्रता में कमी आई है। जुलाई माह में ऐरोसॉल की सांद्रता में वर्षा की वजह से अपमार्जन के कारण कमी आती है। सापेक्षिक आर्द्रता के साथ ऐरोसॉल की सांद्रता की भिन्नता को वायुमंडल में बनने वाले संघनन के अनुसार स्पष्ट किया गया है। इस अवधि के दौरान ऐरोसॉल के वितरण को अभिलक्षित करने में मौसम विज्ञान के प्राचल महत्वपूर्ण भूमिका निभाते हैं।

ABSTRACT. The atmospheric aerosol concentration has been measured at Roorkee (29°52' N, 77°53' E and hmsl 275m) during November 1998 to August 1999 at a height of 9m above the ground level. The variation of aerosol concentration has been studied in view of some meteorological parameters like relative humidity, temperature, rainfall and wind speed during the period from April-July, 1999 at Roorkee. The measurements were done with the help of an optical particle counter. The counter monitors the number concentration of aerosols in the size range from 0.3 to 5.0 μm. This size range is mainly responsible for the optical effects and radiation budget in the atmosphere. The aerosol concentration for large size ranges (1.0-2.0 μm and 2.0-5.0 μm) has a tendency to be higher in the month of June due to prevailing meteorological conditions and minimum during July. Further, aerosol concentration in the small size ranges (0.3-0.5 μm and 0.5-1.0 μm) decreases monotonically up to the end of July. The decrease of concentration of aerosols in the month of July has been attributed to the scavenging due to rain. The variation of aerosol concentration with relative humidity has been explained in terms of condensation taking place in the atmosphere. During this period the meteorological parameters play important role in characterizing the aerosol distribution.

Key words – Aerosols, Size range, Meteorological control of aerosols.

1. Introduction

Aerosols play an important role in the atmosphere. They control the atmospheric radiation budget and hence are important in the variation of weather and climate. Therefore, a study on the variation of atmospheric aerosol concentration in relation to their dependence on some meteorological parameters during the period of April-July, near the earth surface was carried out. The atmospheric aerosols are generally hygroscopic, and relative humidity plays very important role in the radiative property of aerosols (Parmeswaran and Vijay Kumar, 1994). Hanel (1976) investigated the change in aerosol properties as a function relative humidity. Devera and Raj (1998) have tried to find out some relationship between meteorological parameters and columnar aerosol distribution. Aher and Agashe (1997) studied the effect of premonsoon scenario on aerosol at Pune. Hanel and Lehmann (1981) and Shaw

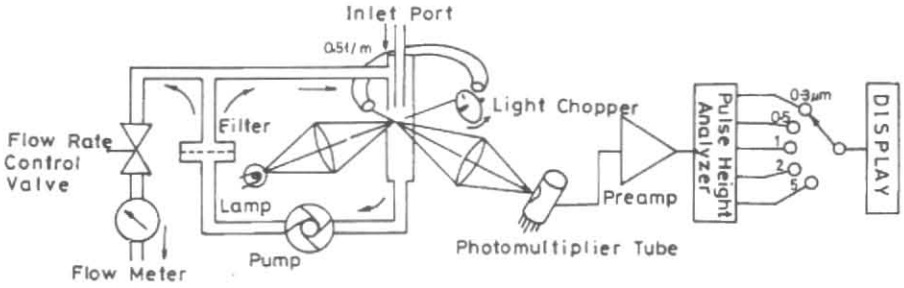
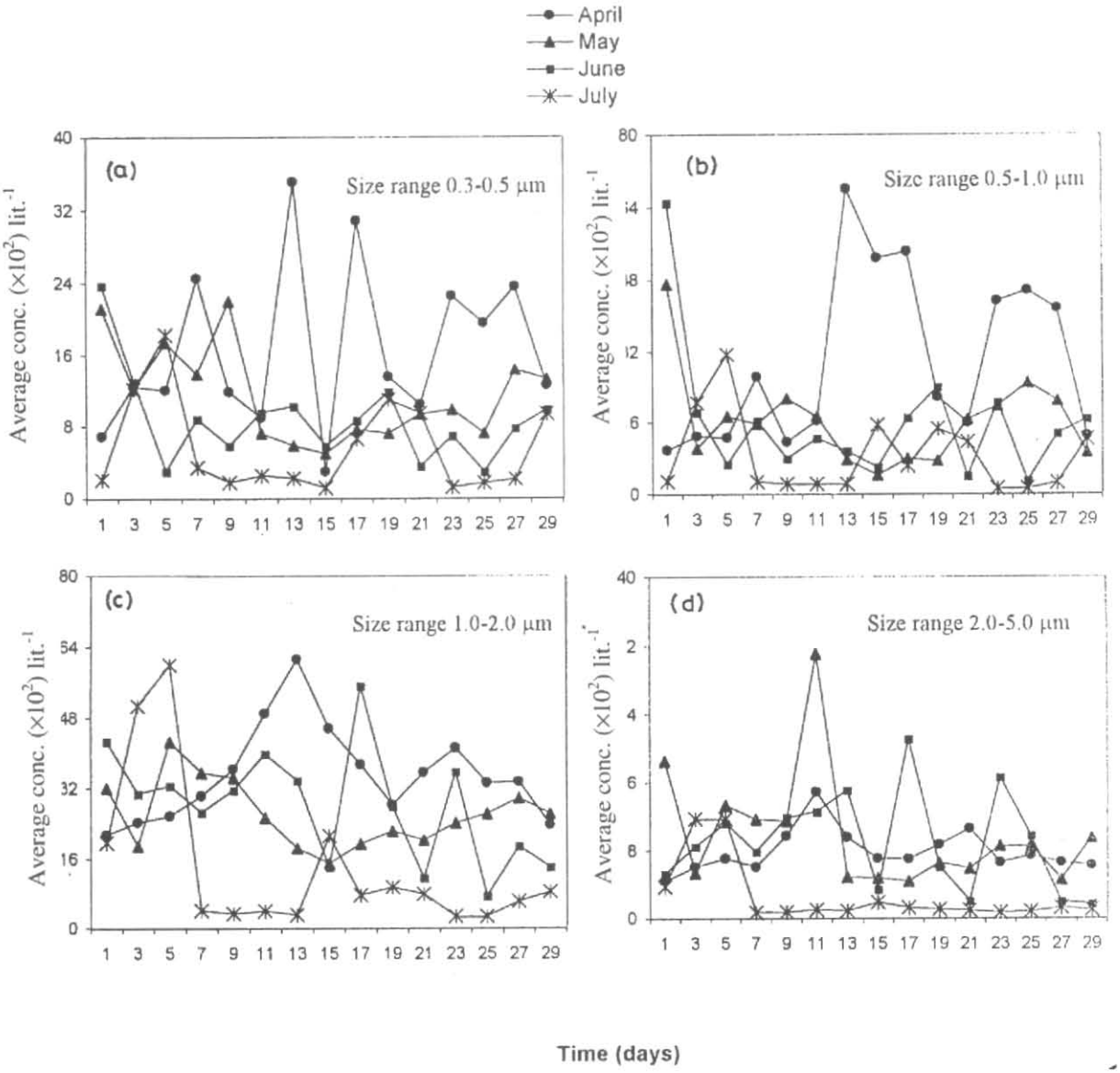
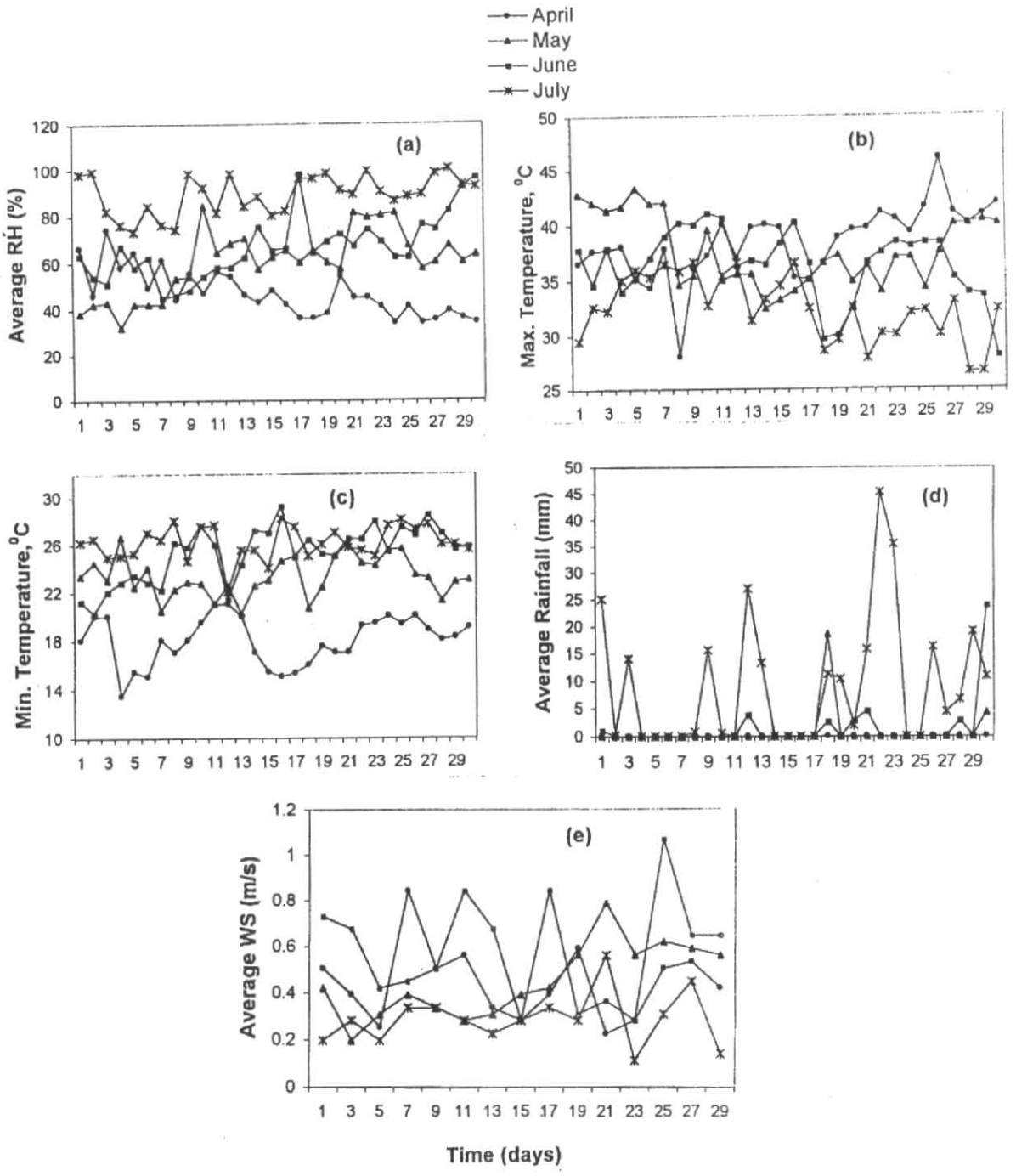


Fig.1. Internal layout of particle counter

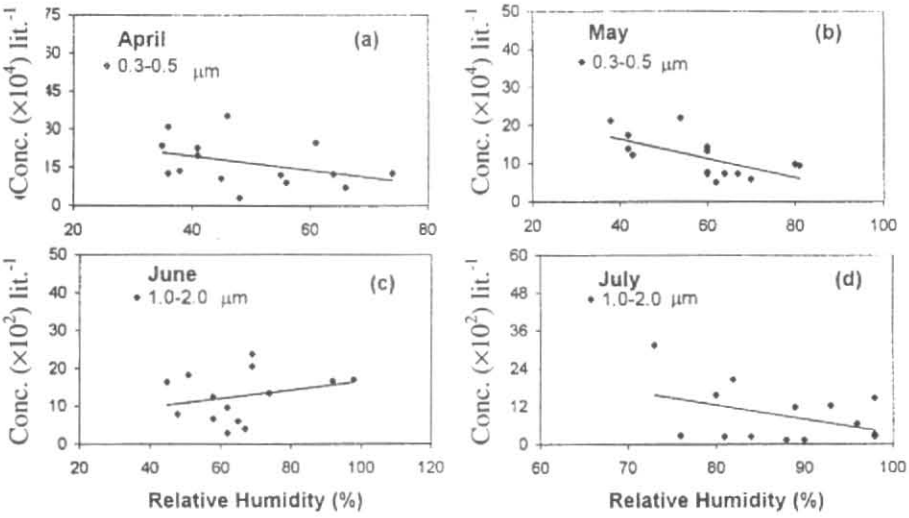


Figs. 2(a-d). Variation of average concentration of aerosols during April-July, 1999 for different size ranges (0.3-0.5 μm, 0.5-1.0 μm, 1.0-2.0 μm and 2.0-5.0 μm) shown by a, b, c, d respectively



Figs. 3(a-e). Variation of average meteorological parameters (relativity humidity, max. & min. temperature, rainfall and wind speed) during April-July, 1999 shown by a, b, c, d & e respectively

(1988) have tried to study the size distribution of atmospheric aerosols in different meteorological conditions. The radiative properties and effect of warming due to greenhouse gases in the atmospheric region in which the aerosols are distributed has been studied by various workers (Krishnamurthy, 1988). While such



Figs. 4(a-d). Variation of average aerosol concentration *versus* relativity humidity during April-July, 1999 shown by a, b, c & d respectively for different size ranges

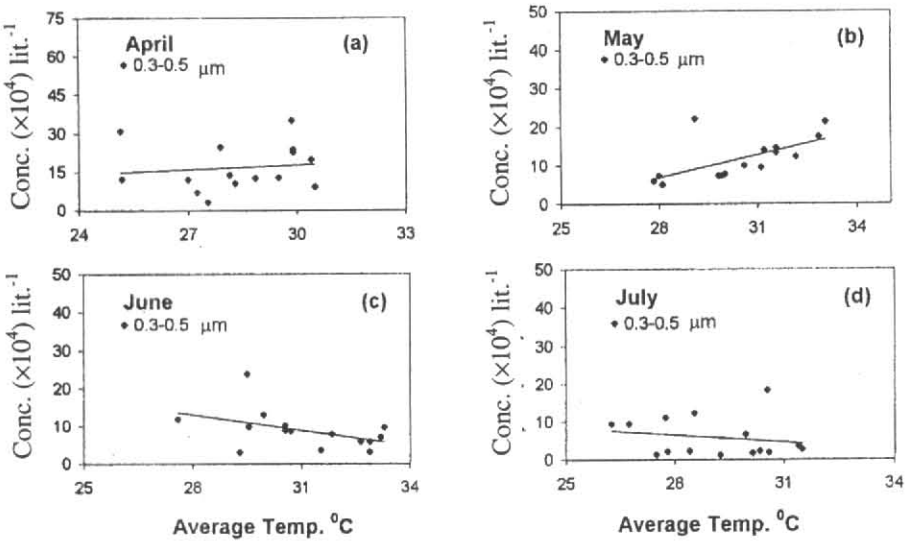
studies have been carried out at high latitudes (Harshvardhan, 1993). Singhal *et al.* (1985) have studied the diurnal, seasonal and annual variation of aerosols at low latitudes. Pahwa *et al.* (1994) have also studied the aerosol behavior at Delhi.

In the present paper we have tried to study the variation of aerosols in relation to some meteorological parameters during the period April to July, 1999 at Roorkee. The study on aerosol distribution can be done by using various techniques available such as Cascade impactor (Pahwa *et al.* 1994), Lidar (Devara and Raj 1998, Mc Cormick *et al.* 1978), Low pressure impactor (Parameswaran and Vijay Kumar 1994), Laser scatterometer (Singh *et al.*, 1997). For present study, we have measured the aerosol concentration by using an optical counter.

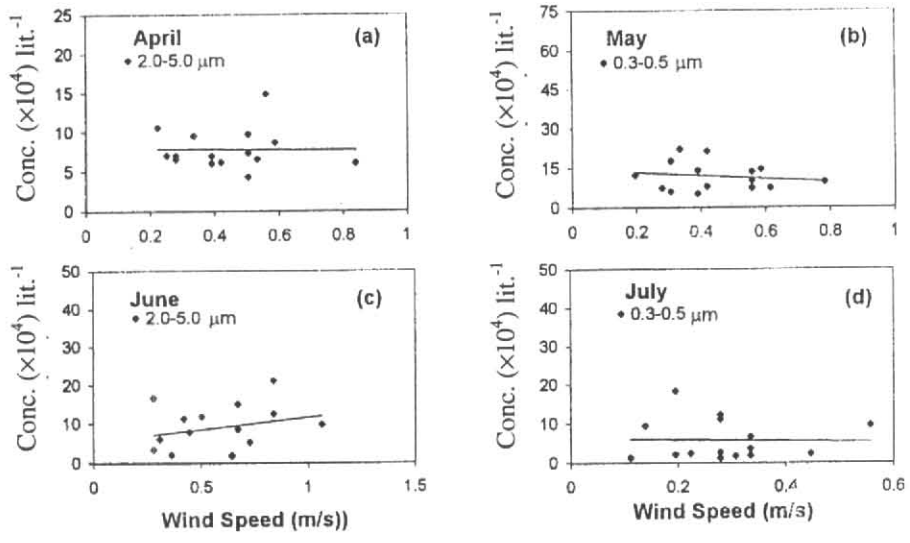
2. Methodology

The number density distribution of aerosols was measured with the help of an optical counter based on the theory of Mie scattering. The ambient air containing aerosols is sucked and a light beam is made to be incident. A sensitive photo detector measures the scattered radiation. The aerosol size is divided into different size ranges with the help of Pulse Height Analyzer (PHA). The PHA detects the scattered pulses of incident radiation by the particles. The pulse height depends upon the particle size. With increasing particle size the pulse height increases and the PHA takes it into account. The instrument (Fig. 1) is the model KC-01A (Rion Co. Ltd. Tokyo, Japan). Observations were made at a height of 9m above the ground, on the second floor of the Physics Department building in the university campus. The University of Roorkee campus is located in the city of Roorkee (29°53'N, 77°53'E) at the height of 275m from sea level. Roorkee city is free from polluting industries and the manmade aerosols are mainly due to household activities and the automobiles. The particle counter monitors the number concentration in four different size ranges *viz.* 0.3-0.5 μm, 0.5-1.0 μm, 1.0-2.0 μm and 2.0-5.0 μm respectively. The observations were taken from November 1998 to August 1999. Everyday the observations were taken continuously from 9:00 AM to 6:00 PM. The concentration of aerosols in the above ranges was recorded at every half an hour interval and the data of meteorological parameters were obtained from National Institute of Hydrology (NIH), Roorkee which is very close to the experimental site.

We have not measured the chemical composition of aerosols at the site of observation. However, most of the aerosols are dust particles blown up by the wind. The soil in Roorkee is sandy and therefore it is hoped that most of the particles at the site of observation contain silica. A part of it may be some organic particles because of agricultural activities going on in vicinity. As the site of observation is far from the busy city and highway, the contribution due to vehicular emission is negligibly small.



Figs. 5(a-d). Variation of average aerosol concentration *versus* average temperature during April-July, 1999 for lowest size range (0.3-0.5 μm) shown by a, b, c & d respectively



Figs. 6(a-d). Variation of average aerosol concentration *versus* average wind speed during April-July, 1999 different size ranges shown by a, b, c & d respectively

3. Results and discussion

The variation of average aerosol concentration with time (days) is shown in Fig. 2 for particles of different size ranges. In the size range 0.3-0.5 μm, the aerosol concentration (Fig. 2a) is about 3×10^5 particles/litre in the month of April. Most of the particles remain in the upper range of 10^5 particles/litre. The concentration of particles is nearly the same in the month of May but it is less in comparison to that in the month of April. In the month of

TABLE 1

The correlation coefficient and empirical relation for aerosol concentration *versus* meteorological parameters during April-July, 1999 for different size ranges

Months	Particle Size (μm)	Relationship: Concentration *Vs* RH		Concentration *Vs* Temp.		Concentration *Vs* WS		Concentration *Vs* RF	
		Fitted Equation	Correlation coefficient	Fitted Equation	Correlation coefficient	Fitted Equation	Correlation coefficient	Fitted Equation	Correlation coefficient
April	0.3-0.5	Y=-0.279X + 30.31	0.383	Y=-0.594X - 0.386	0.112	Y=7.661X + 13.09	0.136	-	-
	0.5-1.0	Y=-033X + 37.21	0.044	Y=2.030X - 22.56	0.323	Y=-14.844X + 41.5	0.221	-	-
	1.0-2.0	Y=0.377X + 3.59	0.926	Y=1.939X - 25.43	0.173	Y=-22.40X + 39.44	0.187	-	-
	2.0-5.0	Y=-0.032X + 9.80	0.181	Y=0.422X - 4.192	0.286	Y=-0.342X + 7.93	0.022	-	-
May	0.3-0.5	Y=-0.322X + 26.95	0.629	Y=1.972X - 48.54	0.619	Y=-5.941X + 14.17	0.175	-	-
	0.5-1.0	Y=-0.238X + 44.96	0.561	Y=2.314X - 44.54	0.514	Y=-6.286X + 28.76	0.131	-	-
	1.0-2.0	Y=-0.176X + 30.36	0.300	Y=2.918X - 72.53	0.469	Y=7.855X - 12.84	0.118	-	-
	2.0-5.0	Y=0.005X + 18.69	0.580	Y=-0.216X + 16.45	0.051	Y=-14.78X + 16.49	0.329	-	-
June	0.3-0.5	Y=0.005X + 8.35	0.017	Y=-1.383X + 51.71	0.462	Y=3.851X + 6.494	0.175	-	-
	0.5-1.0	Y=0.089X + 22.21	0.098	Y=-1.223X + 66.08	0.160	Y=8.116X + 23.33	0.146	-	-
	1.0-2.0	Y=0.110X + 5.10	0.225	Y=-3.605X + 127.9	0.414	Y=5.193X + 12.85	0.081	-	-
	2.0-5.0	Y=0.023X + 7.38	0.058	Y=0.718X - 13.385	0.212	Y=6.211X + 5.32	0.249	-	-
July	0.3-0.5	Y=-.0162X + 19.94	0.266	Y=-0.626X + 23.85	0.201	Y=-1.555X + 6.062	0.033	Y=-0.055X +6.18	0.117
	0.5-1.0	Y=-0.992X + 101.5	0.477	Y=0.332X + 4.281	0.032	Y=-32.87X + 23.40	0.209	Y=-0.21X + 16.09	0.129
	1.0-2.0	Y=-0.448X + 48.06	0.434	Y=-0.747X + 30.25	0.141	Y=-8.512X +10.94	0.109	Y=-0.16X + 10.15	0.201
	2.0-5.0	Y=-0.201X + 20.31	0.455	Y=0.151X - 1.845	0.061	Y=-6.889X + 4.54	0.207	Y=-0.028X +2.85	0.082

June, the concentration of aerosol decreases and most of the particles remain in the concentration range 2.3×10^5 to 9×10^4particles/litre. A further decrease in concentration is observed in the month of July.

This trend continues in the size range 0.5-1.0 μm (Fig. 2b). Most of the particles remain in the range 7×10^4 to 8×10^3 particles/litre in the months of April and May. The concentration in this range decreases in the month of June and July. The lowest concentration goes to 10^3 particles/litre.

In the size range 1.0-2.0 μm (Fig. 2c) the concentration is lower than that in the pervious range. In the month of April the concentration ranges from 2.5×10^2 to 6.4×10^3 particles/litre. It is nearly same in the month of May and is lower in June than July. In the month of July the aerosol concentration varies from 6.4×10^3 to 10^2 particles/litre.

A similar situation prevails in the size range 2.0-5.0 μm (Fig. 2d). During the months of April and May the concentration of aerosol was nearly same (50 to 100 particles/litre). While in June, the concentration increases, ranging from 50 to 200 particles/litre. There is a significant decrease in the concentration in July and most of the particles lie in the concentration range 15 to 50 particles/litre.

The fluctuation of aerosol concentration depends upon meteorological parameters. The relative humidity (RH) was minimum in the month of April (Fig. 3a) and increases in May and becomes maximum in July. In the month of June the RH was less than the month of July. The aerosol concentration is more effected by RH during this period over Roorkee. Parameswaran and Vijaykumar (1994) found that the RH does not affect significantly the aerosol concentration and size distribution up to a limit of 90%. Here at Roorkee in the months of June and July 1999 the average RH was almost close to this limit. Devara and Raj (1998) have observed a higher humidity and lower temperature during Southwest pre-monsoon in the year 1988 at Pune. Aher and Agashe (1997) have studied the effect of premonsoon scenario on aerosols at Pune, which caused the growth of cloud droplets and may results in higher rainfall. The same physical process appears to happen in 1999 at Roorkee during this period. The maximum temperature was lower in April than the month of May and is maximum in June and also decreases in the month of July (Fig. 3b). The minimum temperature was maximum in July and nearly the same in June, lower in the month of April and increases slightly in May (Fig. 3c). The wind speed was nearly the same in the months of April and May (Fig. 3e), effective in June and less in the month of July during the period of observation. The large size (1.0-2.0 μm and 2.0-5.0 μm) particles were least affected by wind and small size particles (0.3-0.5 μm and 0.5-1.0 μm) get carried away by the wind. That is why the concentration of small particles is less in the month of June. The rain plays an important role to modulate the aerosol size as larger particles take part in the scavenging process. In the month of April and May the rainfall was nearly zero (Fig. 3d), so there was no significant affect on aerosol concentration. The SE monsoon is effective after mid of June, so the concentration of aerosol decreases and is in phase with the increasing activity of monsoon. This is attributed to the rainfall, which is a powerful factor to lower the aerosol concentration involving rain out process.

We have calculated the correlation coefficient and have obtained empirical relations of aerosol concentration *versus* meteorological parameters (relative humidity, temperature, wind speed and rainfall). These have been shown in Table 1.

The correlation coefficient, in case of aerosols concentration *versus* relative humidity is large [Figs. 4(a & b)] for lowest size range (0.3-0.5 μm) in the month of April and May. It is large [Figs. 4(c & d)] for larger size ranges (1.0-2.0 μm and 2.0-5.0 μm) in the month of June and July.

The correlation coefficient for aerosol concentration *versus* average temperature is higher (Fig. 5) for lower size particle (0.3-0.5 μm and 0.5-1.0 μm) during the whole period of observation. For the wind speed (Fig. 6) the correlation coefficient is fluctuating and it can be taken to be independent of the size range.

In the months of April, May and June the rainfall is absent. During the month of July the correlation coefficient has a tendency to be higher for large size ranges.

4. Conclusion

The present study reveals the fact that the aerosol size and number concentration is very much affected by the meteorological parameters. The relative humidity, temperature and wind speed play important role to modulate the aerosol behavior at any location but large amount of precipitation (heavy rainfall) can alter the number density and size distribution of atmospheric aerosols more efficiently than RH and wind speed.

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