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RESEARCH ARTICLE

ANALYSIS OF PARTICULATE MATTER (PM_{10} & $PM_{2.5}$) LEVEL AND METEOROLOGICAL EFFECTS DURING WINTER SEASON AT RAJIV GANDHI INSTITUTE OF CHEST DISEASES HOSPITAL CAMPUS IN BENGALURU CITY

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ABSTRACT

The need of study the properties of Particulate matter (PM) and their distribution of particles in different hospital environment and top priority of this study is to control air pollution in hospital environments. $PM_{2.5}$ is the mass concentration of fine aerosol with aerodynamic diameter less than 2.5 µm whereas, PM_{10} is the mass concentration with aerodynamic diameter of 10 µm.PM_{10} and $PM_{2.5}$ were measured in ambient levels at Rajiv Gandhi Institute of Chest Diseases Hospital Area and compared with Victoria Hospital area PM_{10} data. Simultaneously, the meteorological parameters (air temperature, relative humidity, wind speed and wind direction) was recorded by the Envirotech WM 271 wind sensors. The average levels PM_{10} was exceeded the Revised Ambient Air Quality Standards for 123 $\mu g/m^3$(RGICD) & 149 $\mu g/m^3$(Victoria) and $PM_{2.5}$ was in permissible limit 40.37$\mu g/m^3$. Samples of particulate matter were collected during winter season from the hospital area. Qualitative analyses of particulate matter were performed using scanning electron microscope based on morphology the size and shape of the particles.

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INTRODUCTION

Air pollution collectively describes the presence of a diverse and complex mixture of chemicals, particulate matter (PM), or biological material in the ambient air which can cause harm to humans. Humans have always been exposed to ambient air pollutants and have therefore adapted cellular defense mechanisms to protect against agents that may cause disease. Urbanization, industrialization and fossil fuel based transportation led to significant increase in air pollution in urban areas. World health organization considers air pollution as a major public health threat that requires efforts in the areas of research and policy making. Ambient air pollution is composed of a complex mixture of particles, gases and aerosols, which varies depending on the location, source and/or climate. Particulate matter or PM is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. According to report the United Nations environment program (UNEP), the particulate matters are most important pollutants in the world cities (Mage *et al.,* 1996). Elevated levels of $PM_{2.5}$ mass (the mass concentration of fine aerosol with aerodynamic diameter less than 2.5 µm, hereafter referred as $PM_{2.5}$) have been associated with cardiovascular and respiratory problems and even increased mortality rates (Laden *et al.,* 2000; Peters *et al.,* 2001). PM_{10} mass (the mass concentration with aerodynamic diameter of 10 µm) have been associated with allergens. Monitoring of particulate matters in many countries as PM_{10} (particles collected by a convention that as 50% efficiency for particles with an aerodynamic diameter of 10µm), no safe threshold for exposure has been identified. (Dockery and Pope III, 1994) PM_{10} consists of a mixture of particle components, including traffic and combustion derived carbon centered ultrafine particles (less than 100 nm in diameter), secondary particles (nitrates and sulphates), wind-blown dust of geological origin, potentially containing endotoxin, and biological particles (e.g., spores, pollen) with their associated allergens. Air pollution is a significant environmental trigger for exacerbation of chronic obstructive pulmonary disease (COPD), leading to increasing symptoms, emergency visits to hospitals and mortality. The sources, characteristics and potential health effects of $PM_{2.5}$ and PM_{10} are very different from each other; the latter can penetrate into the lungs more readily and is therefore more likely to increase respiratory and mutagenic diseases (Schwartz *et al*., 1993). Particle shape and size are critical factors

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controlling the extent to which particles can penetrate into the respiratory tract, how and where particles are deposited, and at what rate particles are cleared form respiratory tract. Furthermore, a large number of smaller particles have a greater reactive surface area than equivalent mass of larger particles and have a higher likelihood of reaching the deepest regions of the lungs, namely the alveolar region. Ultrafine airborne particles below 1µm in diameter have been related to premature death, aggravated asthma, increased hospital admissions, and increased respiratory problems (Hassan, 2006; Ezoo, 2006). There is a strong link between elevated particle concentration and increased mortality and morbidity (World Health Organization (WHO), 2004). Exposure to particulate matter can aggravate chronic respiratory and cardiovascular diseases, alter host defenses, damage lung tissue, lead to premature death, and possible contribute to cancer (Hassan, 2006; World Health Organization (WHO), 2004).

Morphology of PM provides valuable information for the determination of their physical properties & diverse sources.This analysis is also essential for the assessment of health & ecological effects of airborne particles. Bengaluru city is one of the IT hub in India, in addition the industries, commercial, education, recreational and traffic activities in Bengaluru are higher. In recent decades, Bengaluru has significant growth and urban development and energy use. Thus, air pollution is considered as a serious threat to the environment and health of the people. In this context, the objective of our institute is to conduct research in the area of air pollution related lung diseases, early diagnosis and preventative measures among public and vulnerable groups against lung diseases because environment places a very important role in causation of lung diseases and majority of the times they are treated symptomatically with some antibiotics and bronchodilators without going into their environmental occupational & socio-economic conditions. The lungs are the most common organs affected by environmental changes; Urbanization, Industrialization and pollution from motor vehicles have resulted in significant increase in respiratory diseases. The lungs, with their combined surface area of greater than $500m^2$, are directly open to the external environment. Thus structural, functional or microbiological changes within the lungs can be closed related to epidemiological, environmental, occupational, personal and social factors. Primary respiratory diseases are responsible for a major burden of morbidity and untimely deaths, and the lungs are often affected in multi system diseases. Large scale industrialization, population inflow and rapid urbanization coupled with unfavourable meteorological conditions often induce significant degradation of urban environment. In order to assess the extent of environmental impacts due to establishment of the industries increases in motor vehicles in the Bengaluru city ambient air was monitored from November 2015 to February 2016 in hospital area. As this institute dealing with patient care of respiratory symptom we focus to do research and development in the field of environment health with respect to air Pollution related diseases and measurement of air quality with respect to variation in weather characteristics in our hospital environment. The main objective of this study is to contribute the accumulated knowledge on air pollution in the form of particulate matter $PM_{2.5}$ and $PM_{10,}$ meteorological variables effects on our hospital environment were evaluated from November 2015 to February 2016. The mean mass concentration was recorded every 8hr.In future we will evaluate PM effects possible connection to the increase in respiratory problems and to investigate possible mechanisms induced respiratory symptoms.

MATERIALS AND METHODS

We utilised data on air pollution, meteorological variables to study any association between changes in particulate concentration and meteorological outcomes.

Site selection

Rajiv Gandhi Institute of Chest Diseases is a 470 bedded teaching Government run Autonomous Super Speciality Institution exclusively devoted to chest disease and thoracic surgery situated in the heart of the city of Bengaluru catering to the needs of entire Karnataka. Hospital is surrounded by 1370 number of tress for environment protection and to breathe clean air. Since breath is life, lung health ought to be as high on the global public health agenda as other basic health issues, such as cardiac health or obesity, but it is not. As per the WHO, the burden of lung diseases is enormous killing more than 10 million people in a year. The sampling point was Rajiv Gandhi Institute of Chest Diseases hospital and Victoria hospital area (source: KSPCB) for air pollution monitoring particulate matter concentrations.

Particulate matter ($PM_{2.5}$ & PM_{10})

PM samples were collected by using (Respirable Dust Sampler Envirotech APM 460BL & Particulate Sampler Envirotech APM 550EL). The sampler has an inlet with $PM_{2.5}$ & PM_{10} cut-off, which collects fine particles less than 2.5 µm & thoracic particles smaller than 10µm this both particles are collectively known as coarse fraction. The particles are collected on PTFE filters with a diameter of 46.2mm and 2µm pore size for $PM_{2.5}$ & GF/A filter papers 8”×10” size of Whatman make. $PM_{2.5}$ & PM_{10} was performed according to standard of National Ambient Air Quality Monitoring Program (NAAQMP). The membrane filters were placed in desiccators at room temperature for at least 24 hours to achieve stable humidity before sampling. Initial and final weightings filters were performed in the laboratory at a temperature and humidity controlled room (T = 25 ± 1°C). For quality control, the monitor was calibrated, and the zero testing of blank filter paper is performed at the beginning and end of the measurement period.

Meteorological variables

Daily meteorological variables was simultaneously recorded by the (Envirotech WM 271) wind monitor, weather parameters sensors that compact weather station measures air temperature, relative humidity, wind speed and wind direction. Temperature was measured using a highly accurate resistor, while humidity was measured using a capacitive humidity sensor. For our analyses, the average daily temperature was calculated by averaging the maximum and minimum hourly measurements in °c and Relative humidity in percentage. Wind run, a measurement of the amount of wind passing through the station, was calculated for each 24 h period for the analyses.

Scanning Electron Microscope Analysis

The samples were subjected to electron scanning microscope (SEM) at Indian Institute of Science, Bengaluru, for determination of morphology of airborne particles. Filter papers of PM $_{10}$ & PM $_{2.5}$ of 2cm^2 size were cutted into pieces and placed on the sample counter for gold plating as per the procedure and introduced into the microscopy. The images were taken at a magnification of 3000x, 4000x, 5000x and 10,000x. These magnifications allow to analyse the morphological parameters of particles in the entire particle size range considered.

RESULTS AND DISCUSSION

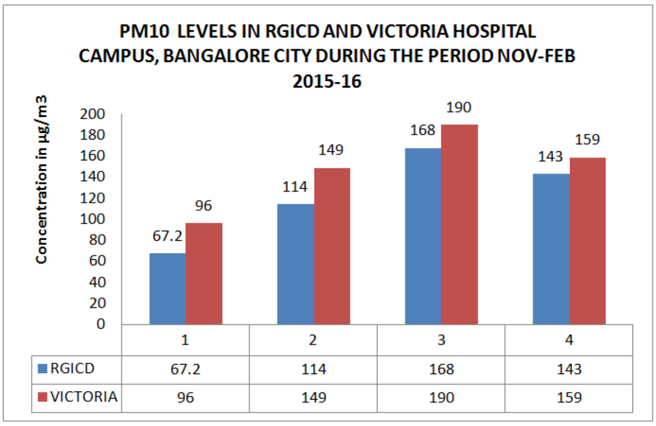
This study describes winter season effect from atmosphere to particulate matter, which associates between concentration levels of particulate matter (PM_{10} & $PM_{2.5}$) and weather effect in both hospitals. During winter season in the month of December, January and February the PM_{10} values exceeded the national limit in both the hospitals, however they is increase in January compared to February and December because in January has got highest humidity, low temperature due to inversion effect (Graph No. 1), $PM_{2.5}$ concentration in ambient air is in permissible limit during winter season in RGICD hospital (Graph No. 2).

Temperature and Humidity

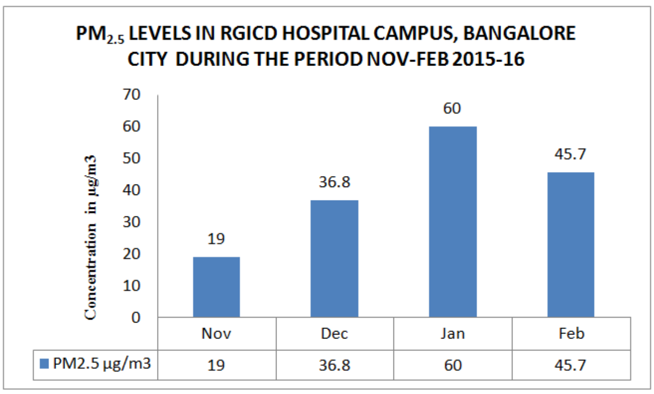
The average maximum and minimum day temperatures recorded on Nov, Dec, Jan, & Feb is 28.2 ºC and 19.7 ºC, average maximum and minimum night temperatures recorded on Nov, Dec, Jan, Feb 2015-16 were 26.8 ºC and 19.7ºC respectively in the city are indicated in the following Table 1. The average maximum and minimum day humidity recorded on Nov, Dec, Jan, Feb were 87.3% and 44.0%, average maximum and minimum night humidity recorded on Nov, Dec, Jan, Feb 2015-16 were 85.6% and 48.7% respectively in the city are indicated in the following Table 1. The Variation of wind speed as well as wind direction was shown with respect to month. Wind roses at 00:00 to 23:00 hrs according to Indian Standard Time for the month of November have been depicted in (Figure 1). In this month, north western direction with wind speed up to 14.4 km/hr with an angle direction 292.5 to 337.5 which was more predominant. Whereas, in the month of December (Fig.2), mainly west wind speed up to <28.8km/hr with an angle direction 247.5 to 292.5 was predominant and blowing in same direction. In the month of January (Fig.3), mainly in west wind speed and direction up to < 28.8 km/hr with angle range in between 258.75 to 281.25 was predominant and blowing in same direction. whereas in the month of February (Fig 4), mainly in west wind speed and direction up to < 28.8 km/hr with angle range in between 258.75 -281.25 was predominant and blowing in same direction. Fig.1, 2, 3 & 4

Table 1. Maximum & minimum temperature, humidity of winter season

Year (Nov. 2015-Feb. 2016)		Nov 2015	Dec 2015	Jan 2016	Feb 2016	Average
	Day Maximum °C	26.6	28.6	27.6	29.8	28.2
Temperature	Day Minimum °C	20.6	19.7	17.6	20.6	19.7
	Night Maximum °C	23.3	24.2	26.6	32.8	26.8
	Night Minimum °C	20.5	19.9	17.9	20.6	19.7
	Day Maximum%	94.0	89.9	87.0	78.3	87.3
	Day Minimum%	61.6	44.1	40.2	30.4	44.0
Humidity	Night Maximum %	94.6	90.5	80.3	77.1	85.6
	Night Minimum %	77.7	61.8	30.4	25.2	48.7



Graph 1. Winter Season mass concentration of PM 10 (µg/m3)



Graph 2. Winter Season mass concentration of $PM_{2.5}$(µg/m^3)

SEM Analysis

SEM analysis of particles showed a wide range of particle sizes and shapes. According to their size and shape having a physical diameter greater than 0.5µm were analysed. According to diameter size, the dominant particles corresponded to the fine fraction (smaller than 2µm). Based on their morphological analysis two main particle classes were detected, natural and anthropogenic natural particles consist mostly soil dust (minerals) and biogenic (biological fragments, spores, pollen, fungi etc) particles. Soil particles have irregular in shapes and rough surfaces and sometimes from aggregates with irregular shapes and sizes, while biogenic particles were highly structured with rounded shapes and smooth surfaces. Anthropogenic particles emitted from combustion processes were predominantly spherical and rounded with smooth surfaces. Morphological analysis of particulate matter indicated that the dominance of soot particles, mineral particles, cluster and irregular in shape. Fig.5, 6, 7 & 8

DISCUSSION

The study on winter season analysis of PM_{10} mass concentration showed higher in RGICD Hospital (168µg/m^3) in the month of January 2016 & slightly decreased (67.2µg/m^3)

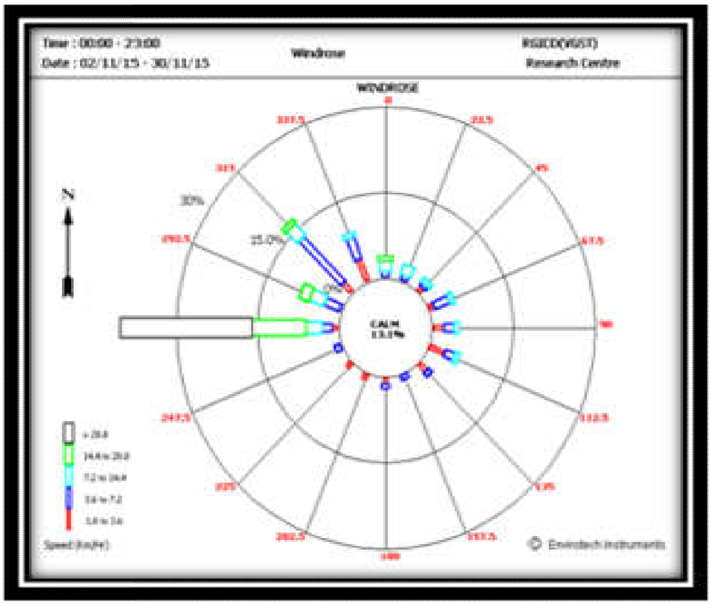


Fig.1. Wind rose at 00.00 to 23.00 hours I.S.T for November

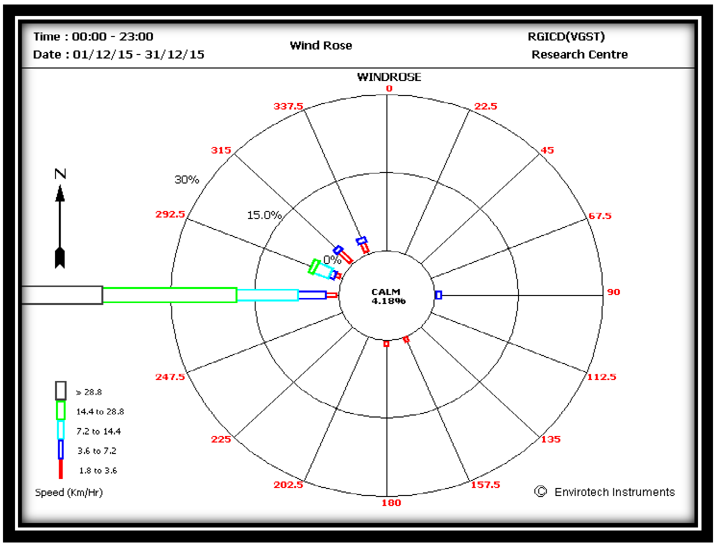


Fig.2. Wind rose at 00.00 to 23.00 hours I.S.T for December

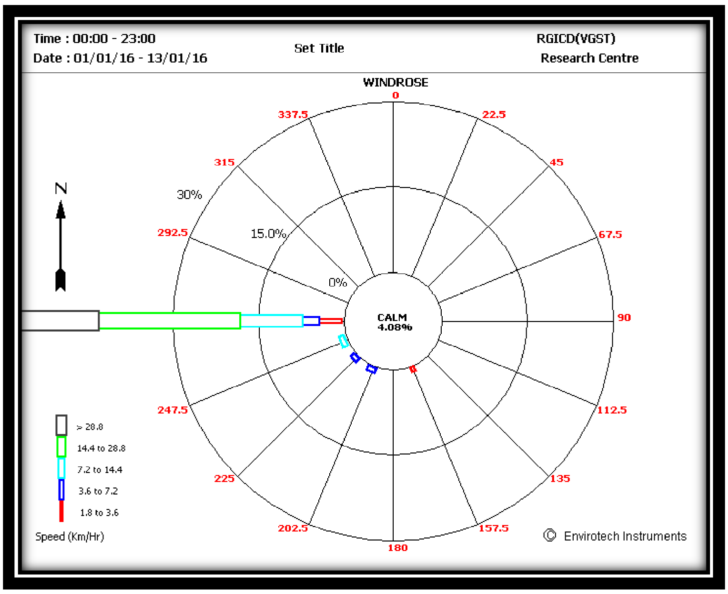


Fig.3. Wind rose at 00.00 to 23.00 hours I.S.T for January

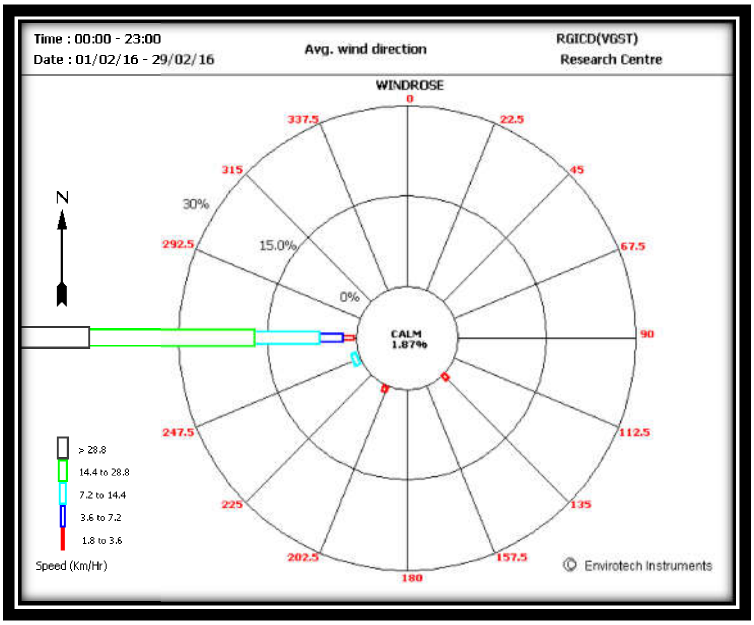


Fig.4. Wind rose at 00.00 to 23.00 hours I.S.T for February

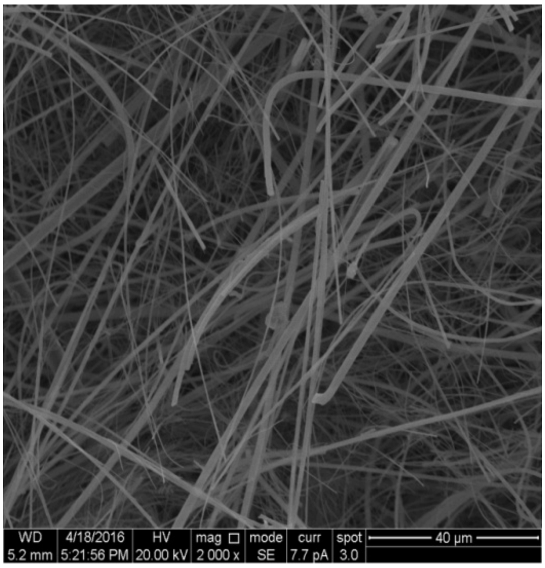


Fig.5.SEM image of PM_{10} before monitoring

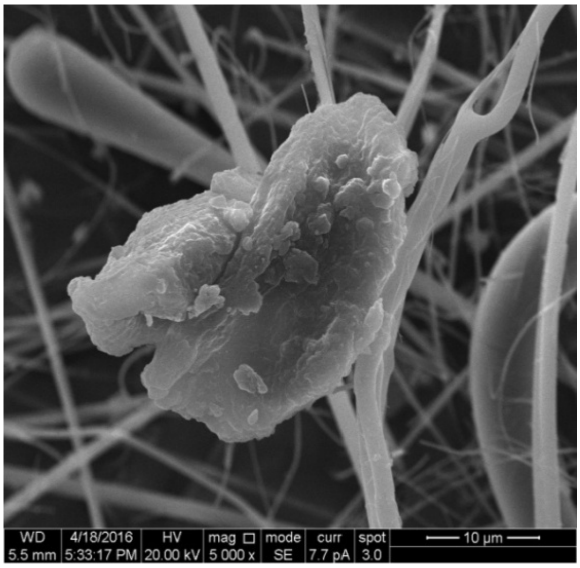


Fig.6. SEM image of PM_{10} after monitoring

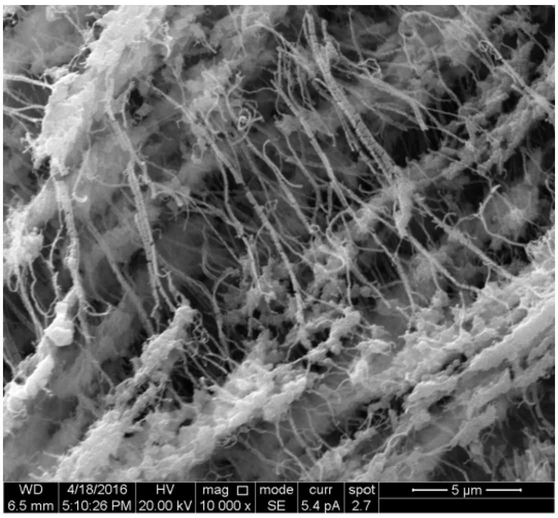


Fig.7. SEM image of $PM_{2.5}$ before monitoring

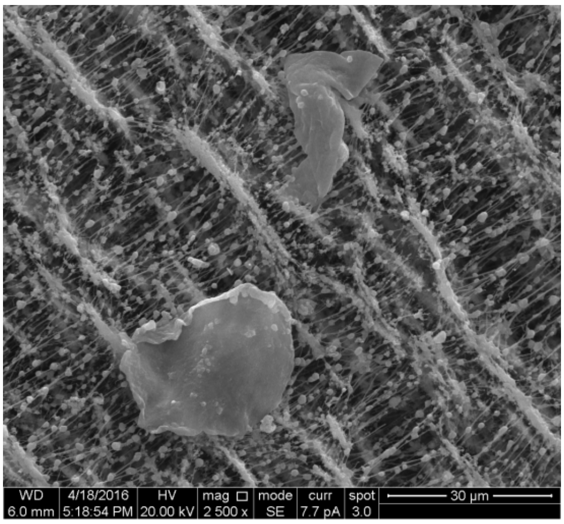


Fig.8. SEM image of $PM_{2.5}$ after monitoring

in November 2015, whereas PM_{10} mass concentration showed higher in Victoria Hospital (190 μg/m^3) in the month of January 2016 & slightly decreased (96μg/m^3)in November 2015. However average of PM $_{2.5}$ mass concentration was (40.37μg/m^3) within permissible limit according to National Ambient Air Quality Standard and average of PM_{10} mass concentration was 123 μg/m^3 (RGICD) and for Victoria - 149μg/m^3. A Study in Agra on seasonal analysis also showed the higher number concentrations of $PM_{2.5}$ (97.2 μg/m^3) and PM_{10} (242 μg/m^3) were found during winter followed by post-monsoon, summer and monsoon season (Atar Singh Pipal *et al*., 2014) In our present study, During the month of November 2015 minimum & maximum temperature was recorded (day-20.6°C, 26.6°C, night-20.54°C, 23.37°C) December 2015 (day-19.7°C, 28.6°C, night-19.9°C, 24.2°C), January2016 (day-17.6°C, 27.6°C, night-17.9°C, 26.6°C) and February 2016 (day-20.8°C, 29.8°C, night-20.6°C, 32.8°C), simultaneously PM_{10} mass concentration was recorded in the month of November (67.2μg/m^3) December(114μg/m^3), January(168μg/m^3) and February(143μg/m^3), PM $_{2.5}$ mass concentration was recorded in the month of November(19 μg/m^3), December(36.8 μg/m^3), January(60 μg/m^3) and February(45.7 μg/m^3).Therefore PM_{10} was high in January because of low temperature and more humidity in winter season. During the month of November 2015 minimum & maximum humidity was recorded (day-61.6 %, 94.0 %, night-77.7 %, 94.6 %) December 2015 (day-44.1%, 89.9 %, night-61.8 %, 90.5 %), January 2016 (day- 40.2 %, 87.0 %, night-30.4 %, 80.6 %) and February 2016 (day-30.4%, 78.3 %, night-25.2 %, 77.1 %) respectively. Therefore we have received highest humidity is in the month of November in winter season.

Monthly average wind speed in the month of November 2015 minimum & maximum was recorded (35.1 km/hr, 4.7 km/hr) December 2015 (55.1 km/hr, 6.5 km/hr January 2016 (63.3 km/hr, 7.6 km/hr) and February 2016(54.4 km/hr, 9.4 km/hr). A study conducted in Agra was also reported that higher concentration of $PM_{2.5}$ and PM $_{10}$ during winter season which also suggest that the higher concentrations of PM during the winter period may be due to variation of wind speed, low temperature, moderate relative humidity which resulted to poor dilution of pollutants during this season. It was observed that higher concentrations during winter & pre-monsoon seasons (low temperature) due to very frequent & persistent thermal inversion & foggy conditions at ground level causing a considerable amount of aerosols to accumulate in lower layers of the atmosphere (Kulshrestha *et al.,* 2009a) but we have found, PM_{10} mass concentration was higher and PM $_{2.5}$ mass concentration within permissible limit during winter season in Bengaluru because of low temperature and relative humidity in winter season.

Conclusion: In conclusion, the investigation of relation between particulate matter & meteorological variables in Rajiv Gandhi Institute of Chest diseases hospital and Victoria hospital area of Bengaluru in winter season. The level of PM_{10} increased (168 μg/m^3 in January, 143 μg/m^3 in February, 114μg/m^3 in December) and slightly decreased (67.2μg/m^3) in November whereas in Victoria hospital PM_{10} increased (190 μg/m^3 in January, 159 μg/m^3 in February, 149μg/m^3 in December) and slightly decreased (96μg/m^3) in November that exceeded the National standards limits and PM $_{2.5}$ mass concentration (19 μg/m^3 in November, 36.8 μg/m^3 in December, 60 μg/m^3 in January, 45.7 μg/m^3 in February) in ambient air is in permissible limit during winter season. Scanning Electron Microscopy indicates the morphology of the particles varies size 1.1μm to 29.62 μm of particulate matter. Morphology analyses of individual particles show that non spherical particles of crystal origin were dominate in all dust samples. Specific topographic conditions around the hospital have an important role in increasing the concentration of particulate matter in this hospital environment. Our findings suggest that we should pay more attention to the health effects of particulate matter pollution and provide appropriate solutions to control particulate matter pollution to improve air quality. Also the entry of vehicles carrying patients to be restricted at the gate itself, from gate to hospital eco-friendly vehicles may be provided (Battery vehicles) so that the premises will be free from vehicle exhaust and resuspension of dust particles.

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