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Monitoring of Particulate Matter in Different Locations and Improvement of Indoor Air Quality in Rajshahi City of Bangladesh

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Abstract- Clean rooms today are highly technological solutions with very high demands on the air cleanliness level. Using kerosene heater for cooking as well as cigarette smoking is important indoor source of fine and coarse particles. It is important to estimate the level of air cleanliness in the cases of new production or reconstruction of a clean room. The air cleanliness level in a clean room is dependent on the quality of the supply air, contamination sources and the design of the ventilation system. By making proper design of air conditioning and ventilation system, the air cleanliness level can be controlled. The number of particulate matter also depends on humidity and temperature in the room at different times. In this study, indoor and outdoor air quality has been measured by an optical particle counter and experimental studies have been carried out to make the indoor air free from particulate matter. Different methods have been prescribed to make the indoor air free from particulate pollution. The results obtained from this experiment can be helpful to take necessary steps to keep the indoor air cleaner.

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Monitoring of Particulate Matter in Different Locations and Improvement of Indoor Air Quality in Rajshahi City of Bangladesh

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Abstract- Clean rooms today are highly technological solutions with very high demands on the air cleanliness level. Using kerosene heater for cooking as well as cigarette smoking is important indoor source of fine and coarse particles. It is important to estimate the level of air cleanliness in the cases of new production or reconstruction of a clean room. The air cleanliness level in a clean room is dependent on the quality of the supply air, contamination sources and the design of the ventilation system. By making proper design of air conditioning and ventilation system, the air cleanliness level can be controlled. The number of particulate matter also depends on humidity and temperature in the room at different times. In this study, indoor and outdoor air quality has been measured by an optical particle counter and experimental studies have been carried out to make the indoor air free from particulate matter. Different methods have been prescribed to make the indoor air free from particulate pollution. The results obtained from this experiment can be helpful to take necessary steps to keep the indoor air cleaner.

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I. Introduction

The Environmental Protection Agency (EPA) of USA lists indoor air quality among the top 5 risks to human health, probably because indoor air can be 2-5 times more polluted than outdoor air. While homeowners can't see the majority of indoor air contaminants, every cubic foot of air breathed carries a mixture of millions of microscopic particles such as pollen, mold spores and dust mite debris. In small concentrations, these particles and gasses may cause discomfort in the home. In significant concentrations, they can cause sickness as these are among the most troublesome triggers of such ailments as asthma and allergies.

Particulate matter is the reason of particle pollution and it is a complex mixture of extremely small particles and liquid droplets suspended in a gas, which is usually air. Particulate pollution made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals and soil or dust particles. These particles can be suspended in the air for long periods of time. Some particles are large or dark enough to be seen as soot or smoke. Others are so small that individually they can only be detected with an electron microscope. Normally they are classified as coarse particles equal or greater than 10 μm and fine particles are less than 2.5 μm. Particulate matter is primarily formed from chemical reactions in the atmosphere and through fuel combustion with insufficient oxygen e.g. motor vehicles, power generation, industrial facilities, residential fire places, wood stoves and agricultural burning. Most people spend most of their time indoors. The most recent nationwide study of time budgets (Robinson and Nelson, 1995), based on interviews with 9.386 respondents in 1993-1994, indicates that US residents spend 87.2%of their time indoors, 7.25 in or near a vehicle and only 5.65 outdoors. This paper deals with field studies of particles indoors and outdoors, concentrating particularly on large-scale surveys of homes and buildings. The observed indoor particle concentrations are presented, together with the contributions of these studies toward understanding important parameters such as air exchange rates, source emission rates and penetration factors.

The manner in which particles are formed determines the size and composition of particles. The four main mechanisms of particulate matter formation described below.

- Physical attrition
- Combustion particle burnout.
- Homogeneous nucleation and heterogeneous nucleation of vapor phase compounds in hot gas streams.
- Release of solids during the evaporation of solids containing droplets in hot gas streams.

II. Experimental Procedure

In this experiment, outdoor and indoor air qualities were measured. The experiments were carried out in four different locations in Rajshahi city to measure the outdoor air quality as well as in Higher Education Quality Enhancement Project (HEQEP) sub project CP-521 office room in Rajshahi University of Engineering and Technology (RUET), Rajshahi for indoor air quality. Rajshahi city is the headquarter of Rajshahi division and is situated in north-western region of Bangladesh at

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latitude 24° N and longitude 88° E. Its total area is 96.69 km^2 (37.33 sq. miles).

a) Measurement of Outdoor air quality

Measurement of particulate matter (PM) was done in four different locations in Rajshahi city. The factors considered, while selecting a location, are:

- the total number of people is living into the location.
- the environmental condition around in location that affects the generation of particulate matter.
- the number of vehicles passing through or near the location and
- the number of industries and factories in or around the locations.

On the basis of above factors the following locations in the city were selected:

- Alupotti crossing.
- RDA market.
- Bus Terminal.
- Kumar para.

b) Measurement of Indoor Air Quality

The Higher Education Quality Enhancement Project (HEQEP) sub project CP-521 office room in RUET, Rajshahi was selected to investigate particulate matter in the room. The particle concentration in a room depends on:

- Ventilation system.
- Number of doors and windows.
- Positioning of doors and windows.
- Length, width and height of the room.
- Use of water heater and cooler in the room.
- No. of air conditioner in the room.
- Penetration rate.
- Indoor air contaminants e.g., chemical, dust, bacteria, gases, vapors.
- Quality of outdoor air.

The number of particulate matter (PM) per unit of volume of the room was measured in both using and not using air conditioner. The room had only one ceiling fan and no ventilator. For measuring the concentration of particulate matter, the following conditions were taken for office room:

- Closing all doors and windows with ceiling fan on.
- Closing all doors and windows with ceiling fan off.
- Opening all doors and windows with ceiling fan on.
- Opening all doors and windows with ceiling fan off.
- Fitting filters to windows with windows open.

The Optical Particle Counter (OPC) SOLAIR-3100 of Lighthouse, UK, was used to measure the particle size distribution in both outdoor and indoor air. The specification of the OPC is given in APPENDIX I and the photographic view of the OPC is shown in Fig.1.

Figure 1 : Photographic view of Optical Particle Counter SOLAIR 3100

The device was operated with battery. The sampling probes were connected to the terminal. By pressing the power switch the device was turned on. Measuring mood, particle size, data storage, data printing, sampling time, frequency, delay and holding times were set up. The particle size range was 0.3 to 25 micrometers. Then sampling time was selected as 30 seconds for measurement. After that the interval was selected. It ranges from 1 sec to 24 hrs. We selected the interval between each measurement was one minute. Count per cubic meter was selected as measuring unit. Then the "OK" key was pressed to conform the setting and then pressed "SET" key to shift the measurement screen. After taking each data the machine was switched off. Once the measurement was finished, the data was dumped from the device. After getting all the data we made the device set at OFF.

III. Results and Discussion

Figs. 2 to 5 show the particle size distribution in different locations of Rajshahi city for outdoor air quality. From the figures it is clear that Maximum PM was found at Alupotti crossing and then the particle concentration decreases gradually in RDA market (2nd floor), Bus Terminal and Kumarpara. The total number of people staying in Alupotti crossing was maximum compared to the other locations. The number of vehicles, density of the shops and number of industries and factories around that location was also greater compared to RDA market, bus terminal and Kumarpara which made the difference of particle concentration of that locations.

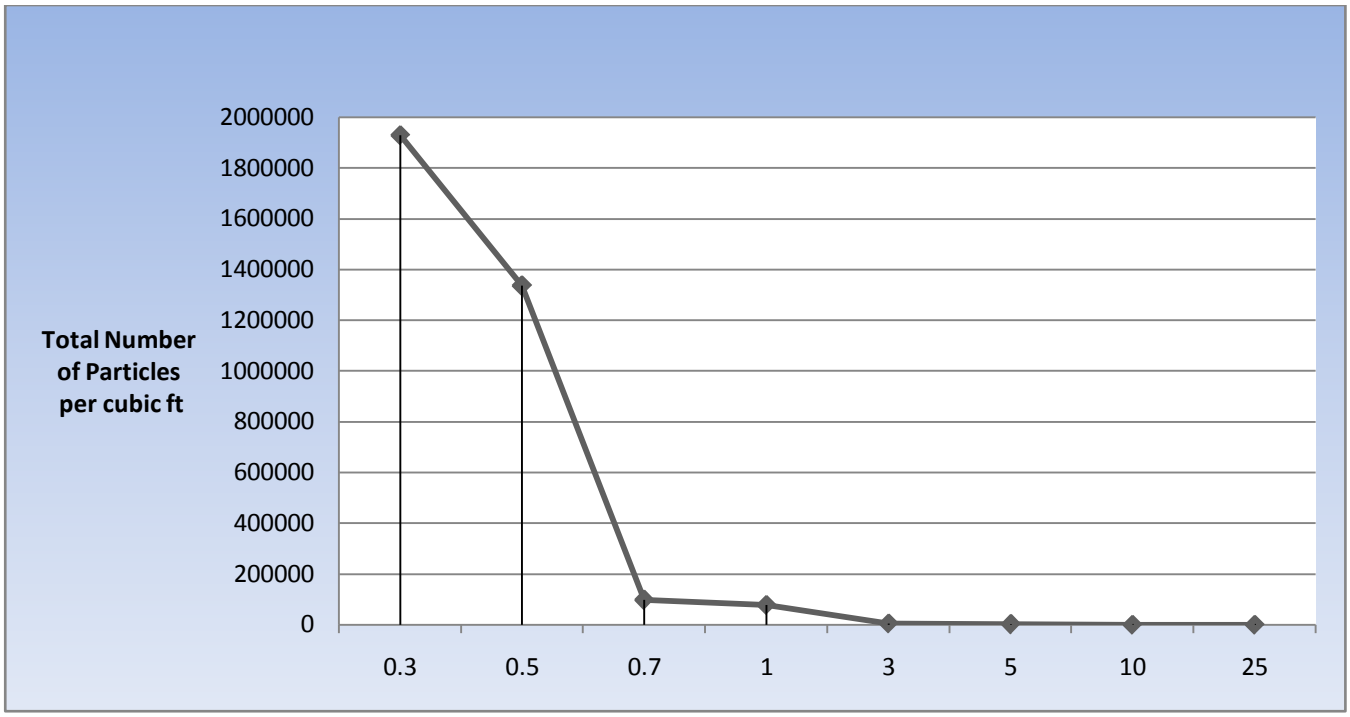

Figure 2 : Particle size distribution at Alupotti crossing at 12:10PM on 20-07-2013

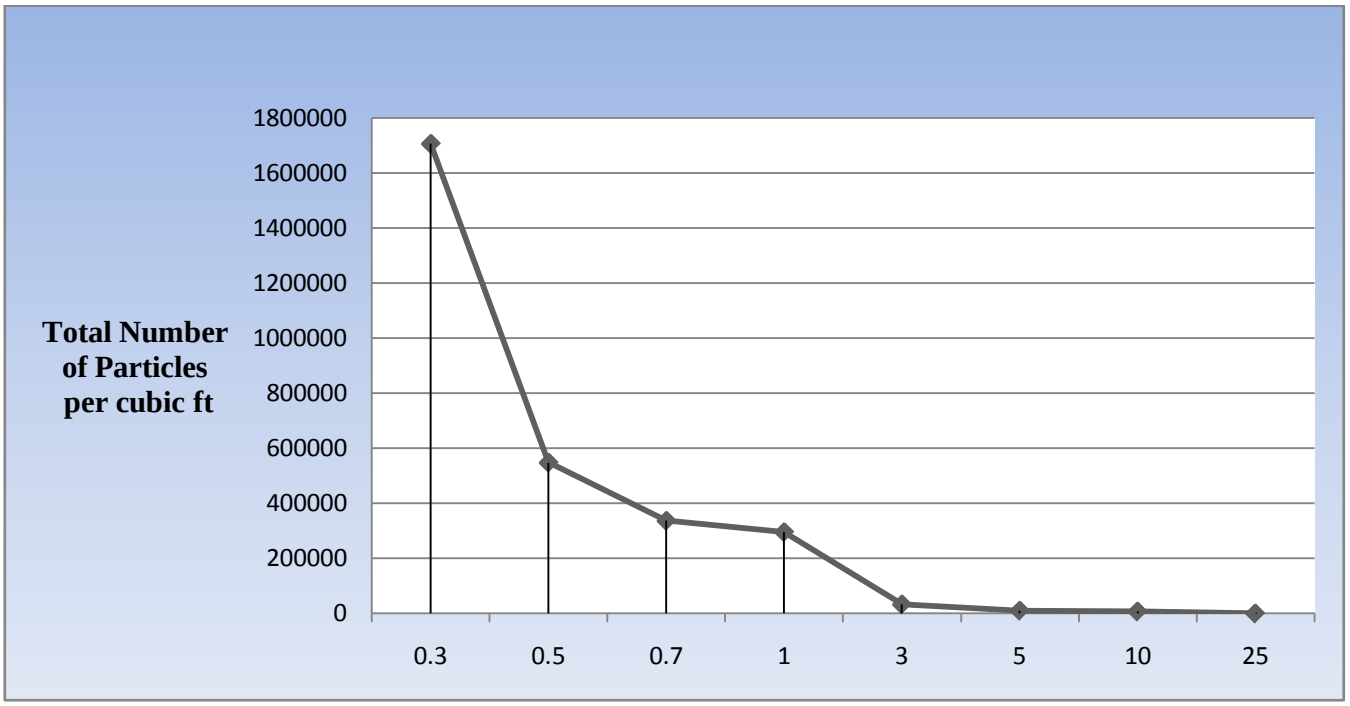

Figure 3 : Particle size distribution at RDA market at 12:20PM on 20-07-2013

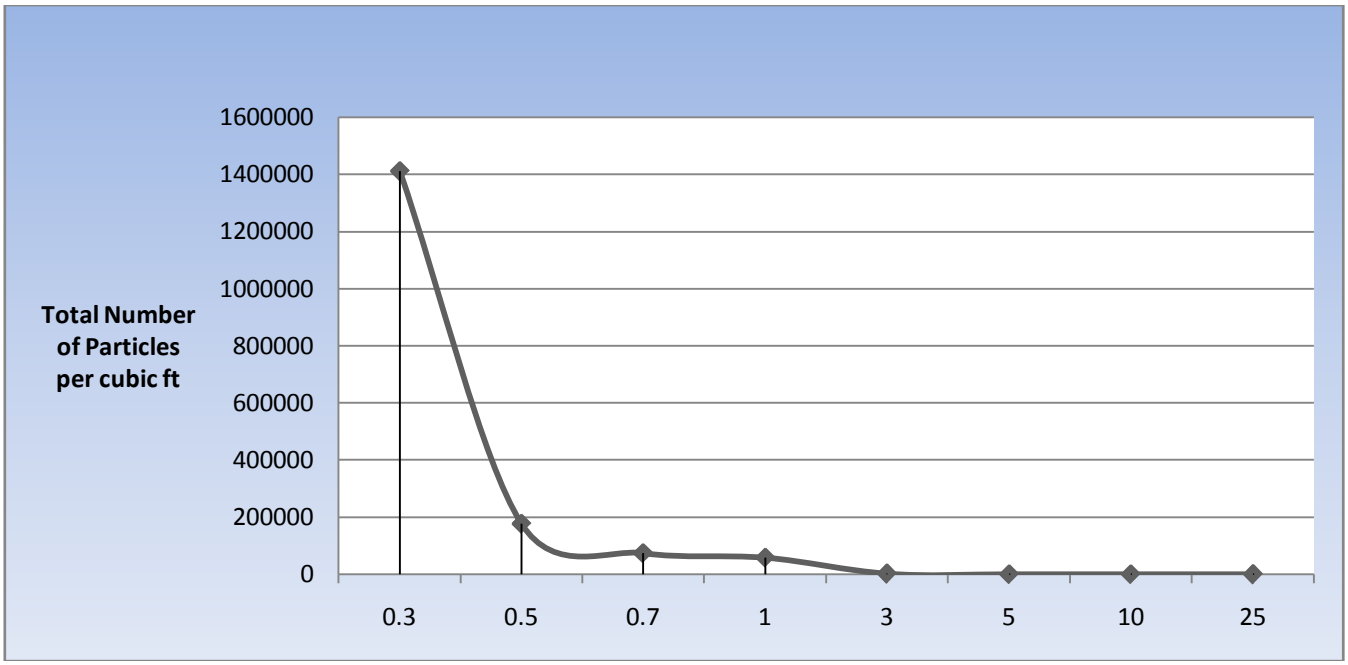

Figure 4 : Particle size distribution at Bus Terminal at 12:35PM on 20-07-2013

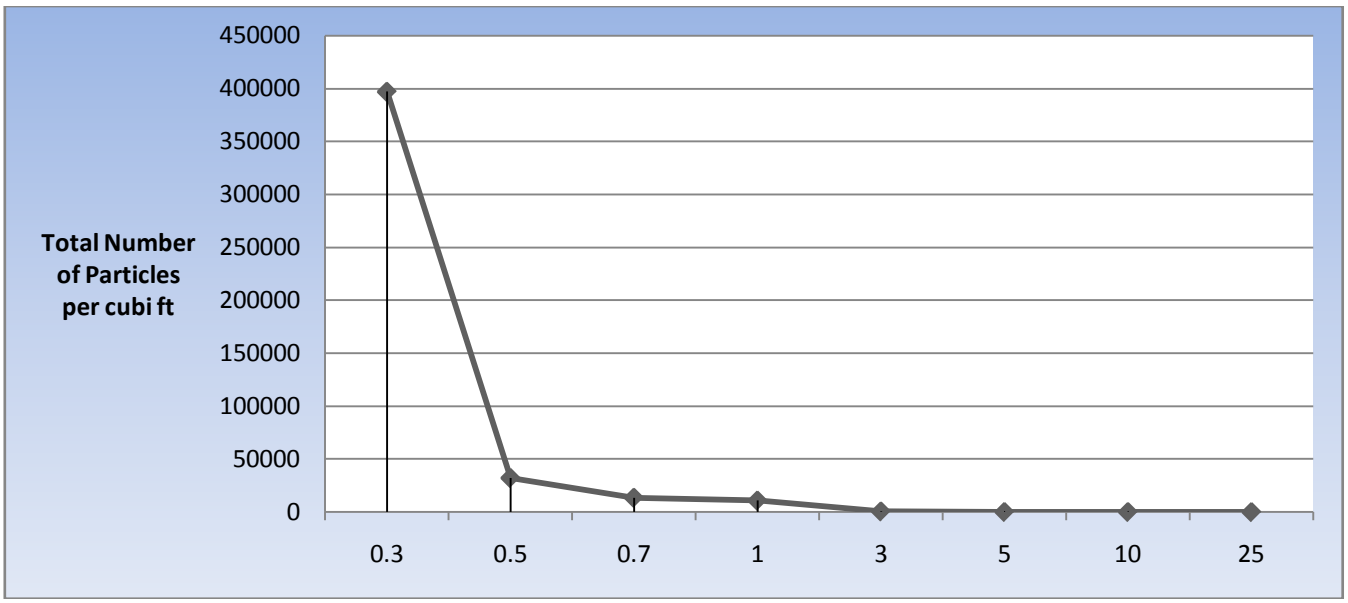

Figure 5 : Particle size distribution at Kumarpara at 01:10PM on 20-07-2013

The indoor air quality in HEQEP sub project CP-521 office room has been shown in Figs. 6 to 8. The figures show that the particle concentration was higher in non air conditioning room than air conditioning room. The particle concentration was also varied due to opening and closing the doors and windows with the ceiling fan on and off. The particulate matter was maximum when all the doors and windows were open and the ceiling fan was off. The particulate matter was reduced by fitting filters into the windows.

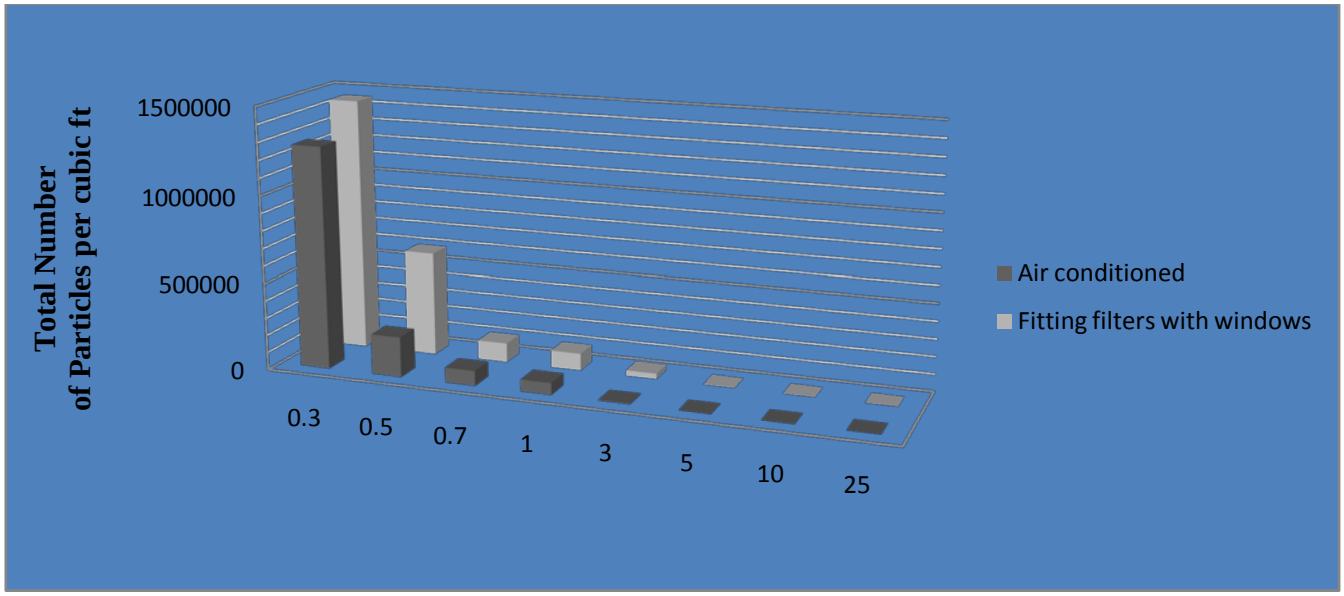

Figure 6 : Particle size distribution in HEQEP sub-project CP-521 office room at 11.20AM on 02-07-2013

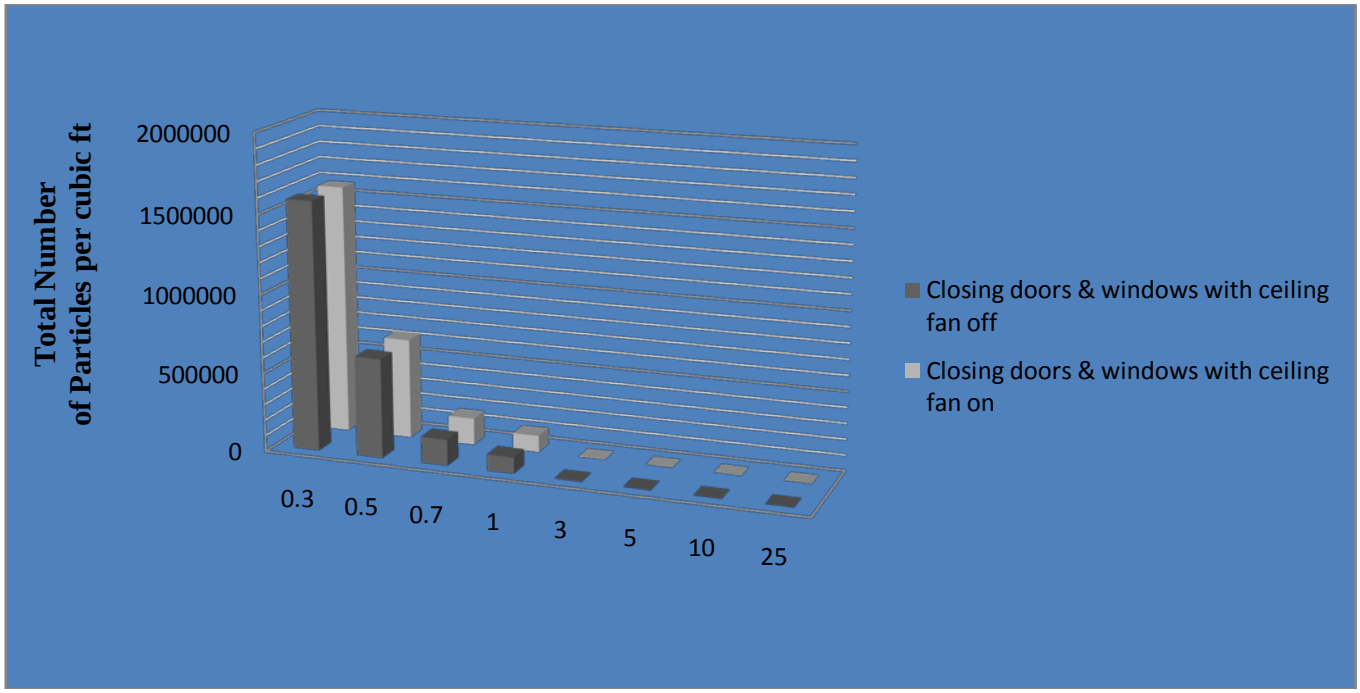

Figure 7 : Particle size distribution in HEQEP sub-project CP-521 office room (Non AC) at 11.40AM on 02-07-2013

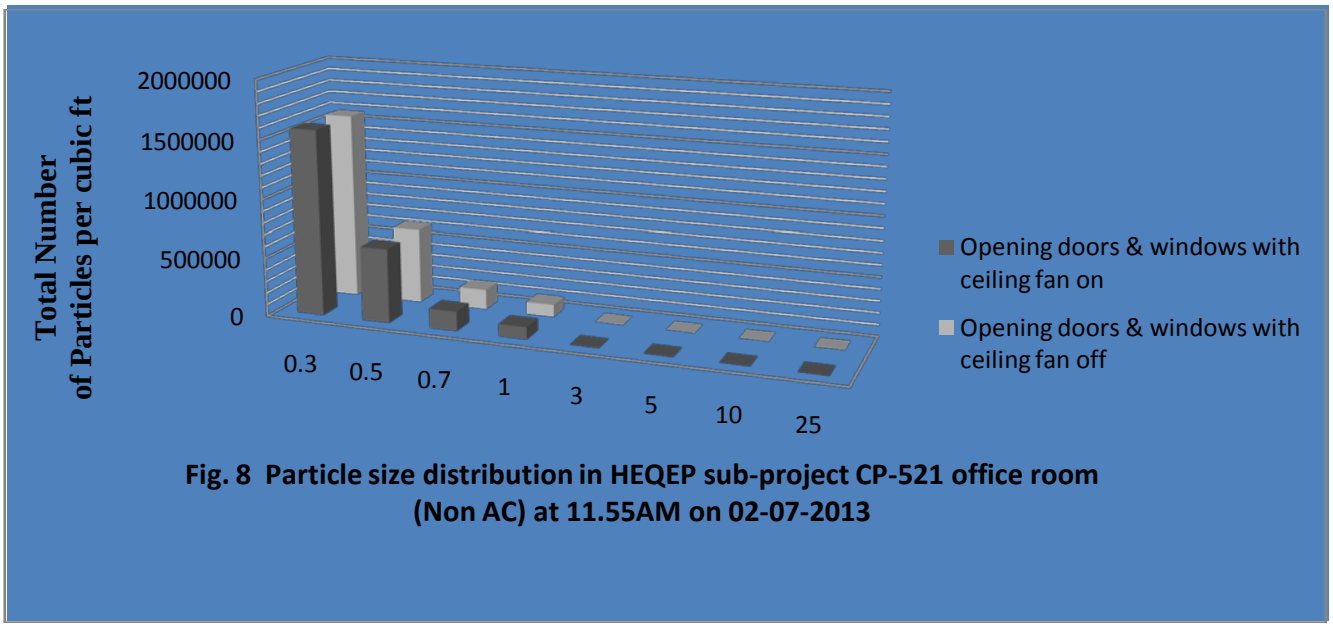

Fig. 8 Particle size distribution in HEQEP sub-project CP-521 office room (Non AC) at 11.55AM on 02-07-2013

Figure 8 : Particle size distribution in HEQEP sub-project CP-521 office room (Non AC) at 11.55AM on 02-07-2013

IV. Conclusions

From the experimental investigations, the following conclusions may be drawn:

- Out of the places in which data were taken, outdoor air quality is the dirtiest in Allupatti crossing in Rajshahi city
- Cleanest indoor air can be achieved by fitting sub-micron filters in doors and windows of the room.

V. Acknowledgements

The Authors wish to acknowledge with appreciation and pleasure the management of Higher Education Quality Enhancement Project (HEQEP) of University Grants Commission (UGC) for their co-operation and financial support extended to complete this research work, which has been carried out as a part of sub-project CP-521 in Mechanical Engineering Department, RUET, Rajshahi.

Appendix I

Specification of Airborne Particle Counter (OPC) SOLAIR-3100

Channel Thresholds	0.3,0.5,0.7,1.0,3.0,5.0,10.0,25.0 μm
Flow rate	1.0 CFM (28.3LPM)
Counting Efficiency	3100:50%@0.3 μm;100% for particles>0.45 μm(PER JIS) 5100:50%@0.5 μm;100% for particles>0.75 μm(per JIS)
Laser Source	Extreme Life Laser Diode
Zero Count Level	< 1 count/5 minutes (per ISO 21501-4)
Concentration	500,000 particles/ft3@5%Coincidence

Limits	Loss
Calibration	NIST Traceable
Count Modes	Concentration, manual, automatic, beep
Data Storage	Stores up to 3000 sample records of particle and environmental data, plus location and time
Communication Modes	Ethernet TCP/IP, RS485/Modbus. USB,USB Flash Drive
Supporting Software	LMS X Change Data Transfer Software Optional: LMS Express ,LMS Net
Printer	Thermal printer , optional , specify at time of order
Sample Output	Internally filtered to HEPA standard (>99.97%@0.3μm)
Vacuum Source	Internal clean pump , flow controlled
Power	100-240VAC,50-60Hz
Battery	Li-ion , removable and rechargeable
Operating temp/RH	50° F to 104° F(10°C to 40° C)/ 20% to 95% non -condensing

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