ASSOCIATION BETWEEN EXPOSURES OF PARTICULATE MATTER 2.5 AND POLLEN ANTIGENS WITH ACUTE PRECIPITATION OF RESPIRATORY SYMPTOMS: A PERSPECTIVE STUDY IN ADULTS IN A CITY OF INDIA AND AHPCO AS A REMEDY

[1]NABARUN GHOSH, [2]PRABIR BANERJEE, [3]AUBREY HOWARD BS, [4]JEFF BENNERT, [5]JAY VITALE

[1]MAAAAI, Sigma Xi
[2]Life, Earth and Environmental Sciences,
[3]West Texas A&M University, Canyon, Texas
[4]Air Oasis, Amarillo, Texas, United States of America
[5]Air for Life, Harrow Middlesex HA1 1PD, UK
E-mail: [1]nghosh@wtamu.edu, [2]pkbanerjee1@buffs.wtamu.edu, [3]adhoward3@buffs.wtamu.edu, [4]drj@airoasis.com, [5]jayvitale21@gmail.com

Studies have conferred serious health outcomes in people living in polluted areas with fine particulate matter ($PM_{2.5}$) values exceeding permissible limits. Particulate matter with such lesser aerodynamic diameter poses greater respiratory risk factor due to its propensity to reach deep down the lungs and come in contact with the blood. Both short and long term exposures are linked to serious respiratory outcomes. At this outset, a prospective study was conducted on the adult residents of a known polluted area, who developed acute respiratory symptoms on exposure to $PM_{2.5}$ and grass pollen grains over a period of more than a year. In India, air pollution has been the fifth leading cause of death. The study tried to probe the association between $PM_{2.5}$ and grass pollen exposure with daily clinic visits with precipitation of acute respiratory symptoms and its probable relation with seasonal variation throughout the year.A prospective observational study was conducted in a part of city of Howrah in state of West Bengal of Eastern India. The study area was important for having all the four sources of $PM_{2.5}$. The study included all the permanent adult residents (aged >20 yrs. to <70 yrs.) exposed to both ambient air pollutant and grass pollen persistently throughout the year (1-32 pollen/day/mm3). Data of the airborne grass pollen samples were collected using Burkard volumetric sampler and pollen count was obtained. A 24 hours Ambient $PM_{2.5}$ level of the study area was gathered from the official website of State PollutionControl Board. Private clinics of 32 experienced medical practitioners were identified in the locality and daily clinic visits of patients with acute precipitation of allergic upper respiratory inflammation like allergic rhinitis or allergic rhino conjunctivitis or allergic pharyngitis were noted. Data collected were statistically analyzed. Daily mean concentrations of $PM_{2.5}$ in this area was found to be 251.23 μg/m3 which was quite above the permissible limit as enumerated by NAAQS. Daily mean concentration of pollen grains was found to be 6.77 per cubic meter. The mean $PM_{2.5}$ levels followed a trend as the concentrations reached the lowest averages during the summer season, slightly increasing during the monsoon, and reaching its peak during post monsoon and winters. Similarly average grass pollen concentration was found to be minimum in summer or pre-monsoon time, while being at peak in winters. Maximum grass pollen concentration has been observed in monsoon and winters. Average daily clinic visits due to acute precipitation of respiratory symptoms were found to be maximum in winter followed by post and pre monsoon respectively. Management of respiratory symptoms included oral antihistamines and local steroids. There was significant and positive association between personal exposure to both $PM_{2.5}$ and grass pollen with clinic visit due to precipitating respiratory symptoms. Severe Air Quality Index (AQI) was observed in winter and post monsoon time ($p<0.005$).The present study showed mean particulate matter concentration throughout the study period being far above the permissible standard limits. Increased aeroallergen concentration was prevalent in this study site. A seasonal variation of particulate matter and aeroallergen concentration was found to be significantly associated with precipitating respiratory symptoms amongst the residents of this area which upsurges a serious respiratory health concern. Stringent pollution control measures shall help to combat these deteriorating air quality issues thereby promising a healthier, safer and cleaner environment.

Key Words - $PM_{2.5}$ micron, air pollution, allergy, air purifier, AHPCO®

AMBIENT AIR POLLUTION: A GLOBAL CONCERN

Air pollution has been a significant public health problem, responsible for a growing range of health effects that are well documented from the results of an extensive research effort conducted in many regions of the world. A vast population of the developed and developing countries breathe air that does not meet the quality standards as set by World Health Organization Air Quality Guidelines. Air pollution has become a growing concern in the past decade, with an increasing number of acute air pollution episodes in many cities worldwide. Being associated with a broad spectrum of acute and chronic illness, such as lung cancer, chronic obstructive pulmonary disease (COPD) and cardiovascular diseases, ambient air pollution has been responsible for 4.2 million deaths as of 2016. Worldwide, ambient air pollution is estimated to cause about 16% of the lung cancer deaths, 25% of chronic obstructive pulmonary disease (COPD) deaths, about 17% of

ischemic heart disease and stroke, and about 26% of respiratory infection deaths. Major forms of air pollution include aerosols, tiny airborne solid and liquid particles that are released by Earth's surface both naturally and as a by-product of human activities. There are two types of aerosols, primary and secondary. Primary aerosols are made by the activity of human beings which are directly released by motor vehicles (Carbon monoxide) and factories (Sulfur dioxide), while secondary aerosols are mainly the combustion products of different primary aerosols. 90% of aerosols are attributed to natural sources like volcanoes, forest fires, plants, and oceans. Volcanoes release large amounts of ash, sulfur dioxide and other gases into the air. Partially burned organic compounds can originate from forest fires. Some plants produce gases that react with other substances such as smoke, causing the production of aerosols in the air. Micro-algae acting on the ocean produce sulfurous gas known as di-methyl-sulfide found is converted into sulfate in the atmosphere. 10% aerosols are contributed by man-made or anthropogenic sources, produced by burning biomass, fossil fuel combustion, and automobiles. Other sources of anthropogenic aerosols are incinerators, smelters, and power plants. Fossil fuel combustion results in sulfate aerosols, from large amount of liberated sulfur dioxide which reacts with water vapor and other gasses in the atmosphere. Burning biomassfrom farm waste and vegetation to clear land produces smoke which contains organic carbon and black carbon. The majority of sulfates, nitrates, black carbon, and other particles are products of automobile, incinerators, smelters (metal smelting), and power plants. Other forms of aerosols, such as dust aerosols, arise from alteration of the land surface by deforestation (cutting or burning down of all trees in an area), overgrazing (letting animals pass through crops), drought, and excessive irrigation[1].

NATIONAL AMBIENT AIR QUALITY STANDARDS

The U.S. National Ambient Air Quality Standards (NAAQS) are standards for harmful pollutants, established by the United States Environmental Protection Agency (EPA) under authority of the Clean Air Act. The standards are listed in 40 C.F.R. Part 50 (National Primary and Secondary Ambient Air Quality Standards). Primary standards are designed to protect human health, with an adequate margin of safety, including sensitive populations such as children, the elderly, and individuals suffering from respiratory diseases. Secondary standards are designed to prevent damage to property and transportation hazards, and to protect public welfare (including effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility, and climate), economic values and personal comfort and well-being from any known or anticipated adverse effects of a pollutant. A district meeting a given standard is known as an "attainment area" for that standard, and otherwise a "non-attainment area". EPA set NAAQS for six major pollutants as listed hereunder.According to the 2014 WHO report, in 2012 air pollution caused deaths of around 7 million people globally. Worldwide, the main sources of outdoor pollutants are fuel combustion from vehicular transportation, construction and agricultural operations, power plants and industries. Primary pollutants coming from these sources are: carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and polycyclic aromatic hydrocarbons (PAHs). Ozone (O_3) is classified as secondary pollutant since it is formed by reaction between NO_2 and volatile organic compounds (VOCs) in the presence of heat and sunlight. Sulfur oxide pollutants are compounds such as sulfur dioxide (SO_2), a poisonous colorless gas that can form naturally or anthropogenically, and sulfur trioxide (SO_3), which is highly poisonous, highly reactive and extremely corrosive[2].

CLINICAL RESPONSES CAUSED BY THESE MEDIATORS INCLUDING THE $PM_{2.5}$

Urticaria /angioedema: Release of these mediators in the superficial layers of the skin can cause pruritic wheals with surrounding erythema. Angioedema is the swelling of the affected area; it tends to be painful rather than pruritic and is caused when deeper layers of the dermis and subcutaneous tissues are involved.

Allergic rhinitis: Release of these mediators in the upper respiratory tract can result in sneezing, itching, nasal congestion, rhinorrhea, and itchy or watery eyes.

Allergic asthma: Release in the lower respiratory tract can cause bronchoconstriction, mucus production, and inflammation of the airways, resulting in chest tightness, shortness of breath, and wheezing.

Anaphylaxis: Systemic release results in symptoms in multiple organ systems and is considered anaphylaxis. Gastrointestinal system can be affected with nausea, abdominal cramping, bloating, and diarrhea. Systemic vasodilation and vaso-permeability may result in significant hypotension (anaphylactic shock). Allergic reactions can manifest as immediate reactions, late-phase reactions, or chronic allergic inflammation. Immediate/acute-phase reactions occur within seconds to minutes immediately after allergen exposureswelling, nasal discharge,exposure. Few mediators (released from mast cells and basophils) cause eosinophil and neutrophil chemotaxis. These cells along with monocytes and T cells are believed to cause the late-phase reactions that can occur hours after antigen exposure and after the signs or symptoms of the acute-phase reaction have resolved. Late-phase reaction can manifest redness and mucosal airway

narrowing, sneezing, coughing, and wheezing, which can last a few hours and usually resolve within 24-72 hours. Continuous or repeated exposure to an allergen can result in chronic allergic inflammation. Affected tissue sites contain T cells and eosinophils, which canfurther release many mediators causing tissue damage and thus increase inflammation. Repeated allergen challenge can result in increased levels of antigen-specific IgE, which can cause further release of IL-4 and IL-13, increasing the propensity for TH2 cell/IgE–mediated responses.



Fig. 1 The Burkard trap takes samples at the same rate as the inhalation of pollen by normal human as standardized by the Burkard Corporation.

Unit includes the sampling head, a metal drum, and a clock as a part of the head. The clock turns the drum to make a complete revolution in seven days at 2 mm per hour.To collect the samples, the drum was prepared by placing it on the mounting stand and secured with a bolt. A small piece of double-sided tape was placed at the orifice starting positions between the two lines, and a clear one-sided tape with the sticky side up was attached on the double sided tape starting on the black line in the middle, winding the tape all the way around the drum and ended in the black line in the middle of the orifice start position. The head of the spore trap was fixed in place with a pin to prevent the wind from swinging the wind vane. The sampling head (lid assembly) was pulled straight up from the sampler by pressing down and rotating the locking arm 180 degrees. The clock was then wound fully counter clockwise and the new drum was placed on the clock. The drum and the clock were then secured and placed back on the spore trap.

DAILY CLINIC VISIT AND STATISTICAL ANALYSIS

Private clinics of 32 experienced (of at least 15 years duration) medical practitioner were identified in this locality and daily clinic visits of patients with acute (less than 7 days duration) precipitation of allergic upper respiratory inflammation like allergic rhinitis or allergic rhino conjunctivitis or allergic pharyngitis were noted.Data collected was checked for completeness and then statistically analyzed. Descriptive data were represented as mean, standard deviation and range. Different levels were expressed at 95% Confidence Interval.

A P-value of less than 0.05 were considered statistically significant. Mean values were compared with hypothesis testing as found applicable. Correlation analysis was attempted between $PM_{2.5}$levels and aeroallergen with clinic visit.

RESULT AND DISCUSSION

This study identified 32 experienced medical practitioners around the study locality, whose clinics were under the purview and daily clinic visits with acute precipitation of respiratory symptoms like allergic rhinitis or allergic rhino conjunctivitis or allergic pharyngitis were probed. Monthly mean clinic visits were represented. The concentrations of fine particulate matter as well as pollens were observed to vary in different seasons. The mean PM 2.5 levels followed a similar trend as the

concentrations reached the lowest averages during the summer season, slightly increasing during the monsoon, and reaching its peak during post monsoon and winters. Similarly average grass pollen concentration was found to be minimumin summeror pre-monsoon time, while being at peak in winters. Maximum grass pollen concentration has been observed in monsoon and winters. Average daily clinic visits due to acute precipitation of respiratory symptoms were found to be maximum in winter followed by post and pre monsoon respectively. (Table 1).

Table 1 :Daily $PM_{2.5}$, grass pollen concentration and precipitation of respiratory symptoms in terms of seasonal variation

	Mean	Minimum	Maximum	SD
Daily 24 hours $PM_{2.5}$ Concentration				
Pre Monsoon	198.52	91	419	84.40
Monsoon	153.435	25	562	121.30
Post Monsoon	432.52	205	601	81.47
Winter	314.56	33	572	121.36
Average Grass Pollen Concentration				
Pre Monsoon	1.85	0	6	1.47
Monsoon	6.95	0	28	6.52
Post Monsoon	3.25	0	7	1.48
Winter	10.29	1	38	9.46
Average Daily Clinic Visits with Acute Precipitation of Respiratory Symptoms				
Pre Monsoon	17.07	0	35	8.28
Monsoon	9.05	0	24	5.81
Post Monsoon	18.28	9	28	4.27
Winter	21.31	6	43	7.00

There was significant and positive association between personal exposure to $PM_{2.5}$ and clinic visit with precipitating respiratory symptoms. (Pearson's Correlation- 0.340, p= 0.000). Similarly positive correlation was also found with exposure to grass pollen and daily clinic visit (Pearson's Correlation- 0.274, p= 0.000). Based on these categorization, AQI was interpreted in terms ofPM 2.5 levels in all seasons, which showed significantly severe AQI in winter and post monsoon time ($p<0.005$) (Fig. 2).

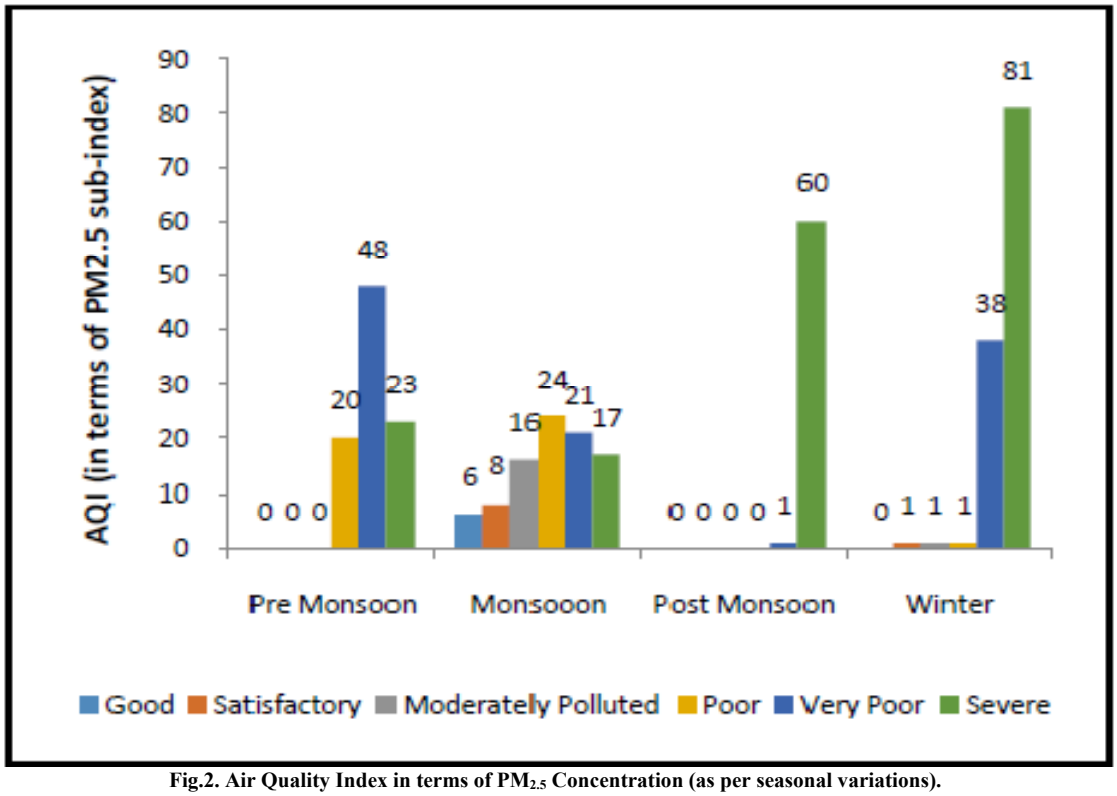


Fig.2. Air Quality Index in terms of $PM_{2.5}$ Concentration (as per seasonal variations).

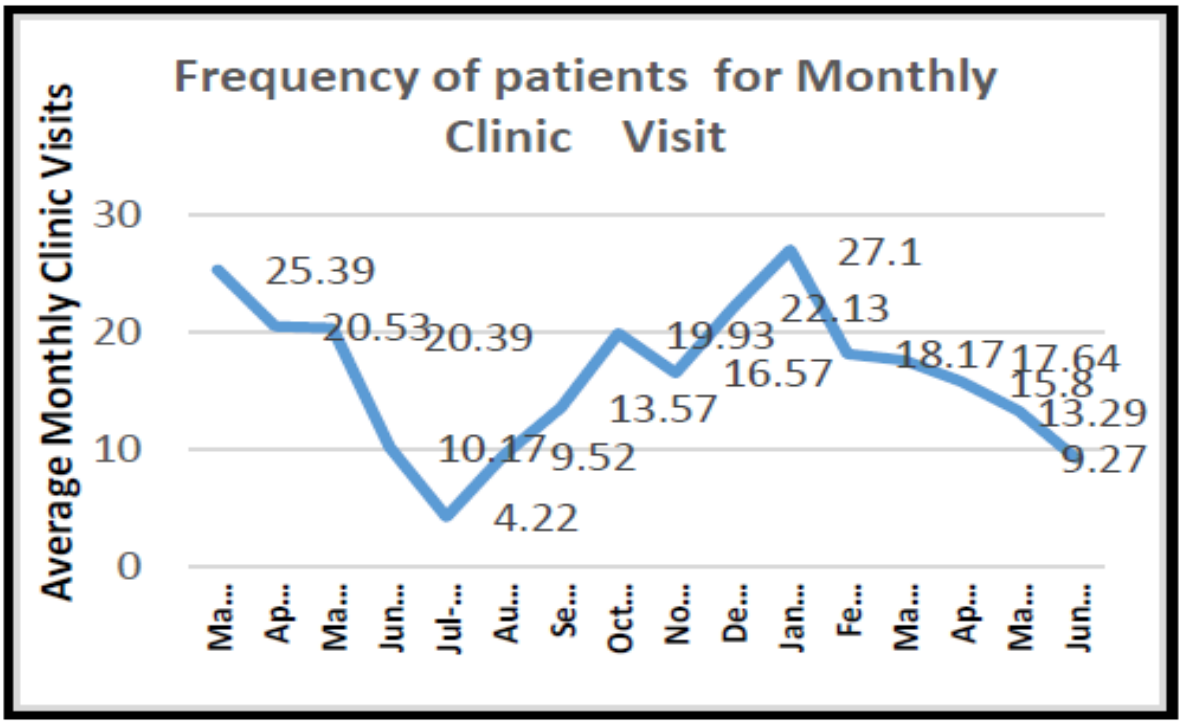


Fig. 3. Mean Monthly Clinic Visits with acute precipitation of respiratory symptoms.

A seasonal variation of particulate matter and aeroallergen concentration was found to be significantly associated with precipitating respiratory symptoms amongst the residents of this area which upsurges a serious respiratory health concern. Stringent pollution control measures shall help to combat these deteriorating air quality issues thereby promising a healthier, safer and cleaner environment.

AHPCO AS A REMEDY FOR THE $PM_{2.5}$

A decade research in aerobiology and biotechnology developed an air purification system that uses Advanced Hydrated Photo Catalytic Oxidation (AHPCO) and Plasma Nanotechnology to reduce indoor aeroallergen to improve air quality and better food preservation.



Fig. 4. Air Oasis air purifiers utilize a new generation AHPCO technology.

It does not just rely on filters or air passing through the air purifier rather in addition to the HEPA filter, it uses the AHPCO nanotechnology to produce the best possible filtration system as implemented in the i-Adapt units.Innovations in technology continue to have massive impact on business and society. The researchers in Dr. Ghosh's Lab at the West Texas A&M University have been assessing the AHPCO and Plasma Nanotechnology for net reduction of bacteria, fungi, VOCs with the specific effect on Methicillin resistant Staphylococcus aureus, MRSA and $PM_{2.5}$[3]. A 5-year research project carried out at the BSA Hospital and Coulter Animal Hospital in Amarillo, Texas evidenced a gradual reduction of airborne bacteria, aeroallergens and VOCs in the indoor air thereby improving the air quality significantly when specialized air purification units were used in the Microbiology and Mycology Laboratories of the BSA Hospital. Evaluations on safety measures showed no side effect on human cell cultures. Indoor aeroallergens such as, airborne fungal spores, airborne bacteria and animal dander reduced significantly on using the air purification units to improve indoor air quality and alleviating breathing ailments.The air purification system developed with novel AHPCO and Plasma Nanotechnology efficiently reduced the indoor particulate matters, fungal spores and animal dander in course of progressive time interval. The major conclusive points from our research are summarized below. Investigation on assessing the efficiency of the AHPCO and Plasma Nanotechnology (Fig.4) used in Air Oasis air purifiers showed the improvement of the Indoor Air Quality (IAQ) by--reducing the indoor particulate matters and aeroallergenconcentration, reducing the MRSA, (the Methicillin Resistant Staphylococcus aureus) concentration[4]. reducing the

VOCs, improving the odor from cigarette smoke5. Assessing the safety measures showed no harmful effect of the AHPCO Air Purification system on the living system and cell culture. From their work it can be recommended that the AHPCO and the Plasma Nanotechnology may be used to reduce the indoor PM2.5 concentration efficiently.

REFERENCES

[1] Simmon, R., &Voiland, A., (2010). Aerosols: Tiny Particles, Big Impact: NASA Earth Observatory. Retrieved from: https://earthobservatory.nasa.gov/Features/Aerosols/

[2] Environmental Pollution Centers, (2017).Web link:

[3] https://www.environmentalpollutioncenters.org/?a=1&y=2017

[4] Ghosh, N., N. Sherali, N. Hiranuma, P. Banerjee, J. Rogers, J. Bennert, J. Vitale, C. Revanna. (2018). Air pollution with 2.5 micron particulate matters, AHPCO® and Bi-Polar units in reducing the indoor particle counts. European Scientific Journal, February 2018. Vol.14, No.6: 26-40 ISSN: 1857 – 7881 (Print) e - ISSN 1857- 7431

[5] Ghosh, N., A. Howard, N. Sherali, C. Revanna, C. Pratt, C. Saadeh, J. Bennert, J. Bennert, K. Mullan and J. Rogers. (2017). Reduction of MRSA populations and Aeroallergens on using AHPCO® and Plasma Nanotechnology for Air Purification. International Journal of Advances in Science, Engineering and Technology, ISSN: 2321-9009, Vol-5, Issue-3-1, Aug.-2017:10-12.

[6] Ghosh, N., C. Estrada, E. Caraway, J. Bennert, J. Bennert, C. Saadeh (2015). New World of Business with Plasma and AHPCO Nano-Technology in Marketing Air Purifier, cell phone and Ice-Maker Sterilizer. (2015). International Journal of the Computer, the Internet and Management (IJCIM). ISSN: 0858-7027. Pp. 9-14.

★★★