NCR Air Pollution

August 11, 2019 1830 hrs.
Agra Express way building from IITD

Reduced Smog

August 11, 2019 1830 hrs.
Badarpur TPP from IITD

Increased Visibility

JNU ENVIS Resource Partner
Geodiversity & Impact on Environment

Ministry of Environment, Forest & Climate Change, Govt. of India
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Cover photographs show a reduction in haze in NCR after EPCA actions in 2018-19. These photographs were taken on August 11, 2019 (Courtesy: Professor Rajesh Khanna, Department of Chemical Engineering, Indian Institute of Technology (IITD), New Delhi).
Dear Readers

Air pollution is a severe problem worldwide. Uniform monitoring of air pollution is very challenging as some factors such as the location of site, altitude from the roadside, temperature, sources in the vicinity, meteorology, equipment sensitivity etc. affect the measurements. Due to these factors, QA/QC in measurements always has been the issue of reliability of data for policy makers. There are a number of publications on different air pollution parameters from different urban and rural sites. Almost all the mega cities in South Asia have air pollution QA/QC problem. This is primarily due to lack of regular calibration of air monitoring analyzers.

In general, the air quality of Delhi is termed unhealthy due to high concentrations of particulate matter. Much of the particulate fraction is contributed by the suspended soil dust. Apart from soil dust, road dust and construction dust also contribute to the high levels of PM$_{10}$ and PM$_{2.5}$. Moreover, Delhi has significant air quality impact from trans-boundary sources such as brick kilns, crop residue burning, heavy duty trucks entering from adjoining states and other outsiders. The crop residue burning (CRB) in Punjab and Haryana states has significant effects on air quality of Delhi. Moreover, the number of vehicles in Delhi has increased from 80,52,508 in 2014 to around 10 million upto March 2018. Deposition of urban dust on the foliar of medicinal plants has been found responsible for morphological and biochemical changes of plants in Delhi. Atmospheric constituents react in a free manner having enormous possibilities and pathways for new products which are dependent on time and space. It means that we need to consider regional sources, meteorology and air composition in the interpretation of results. We need to study indoor air pollution too. Contribution of secondary aerosols is also reported very significantly in the NCR. Diwali celebration also contributes to huge metal air pollution due to fireworks. However, the air pollution of Diwali settles down very quickly within a few days. Ozone pollution is another issue of Delhi. This issue throws light on the recent ozone spikes reported in Delhi.

The continuous efforts of the Environmental Pollution Control Authority (EPCA) and the National Green Tribunal (NGT) towards air pollution control have resulted in a clean NCR. In this process, the Graded Action Response Plan (GRAP) has contributed very significantly. The successful efforts of these regulatory bodies include ban on plastic burning, sealing of illegal tire oil factories, restriction on entry of trucks into Delhi; ban on construction activities, shutdown of brick kilns, ban on diesel generator sets, leaves burning and introduction of odd-even scheme for vehicles etc. These actions
have helped in achieving breathable air. In fact, since November 2018, people of NCR are experiencing better air quality which has further improved tremendously during COVID-19 lockdown.

I would like to mention that the atmospheric dust is not always an evil for us. The higher levels of calcium rich dust is found good for ambient SO₂ scavenging and controlling acid rain in the NCR. The presence of atmospheric dust in the atmosphere in Indian region affects all those reactions where these particles have active interaction. Hence, there is a need to take a holistic view of scenario by integrating all possible reactions, sources, role of predominating species of the region, meteorology, co-emissions, scavenging of pollutants and the existing air pollution controlling regulations etc. for the explanation of results. Since, the main sources of dust are large area sources (Sahara and Thar deserts etc.), the solution for controlling pollutants should be close to natural removal process i.e. wet scavenging through rains. In order to find a solution of high particulate matter in the Delhi region, I suggest creating at least two artificial huge lakes on the periphery of Delhi which can sufficiently moisten the atmosphere through the evaporation of water. Our studies reveal that the rains effectively remove air pollutants. The precipitation through the lakes can remove dust particles as well as gaseous species. It can also control resuspension of road dust by wetting up the soils, recharge ground water, stop desertification, solve future water supply problems in the city. In addition, a tree belt can also be developed around the lake which will be an added advantage.

Professor Umesh Chandra Kulshrestha

Coordinator, JNU ENVIS RP
Reason for High Levels of Ozone in Delhi during COVID-19 Lockdown

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Recently, it has been observed that the ambient concentrations of ozone have increased. This was first noticed in May 2019 (Kulshrestha and Mishra, 2019) at some industrial sites. Much of the explanation about ozone is given based on volatile organic compounds (VOCs) and NOx which are considered major precursors of ozone. But a very different and genuine reason was provided by Kulshrestha and Mishra (2019), who explained the high levels of ozone in Delhi due to less destruction of ozone by the chlorine and hydrochloric acid which was taking place earlier due to plastic burning and pyrolysis of tyres.

The ban on burning of plastic wastes and other polymers is a likely to cause higher $O_3$ levels as it reduces the emissions of chlorine and hydrochloric acid in the air. In 2019, the defaulter industries in the city were closed and a ban was imposed on plastic burning by the Environmental Pollution Control Authority (EPCA) which reduced the HCl and chlorine content in the atmosphere. The HCl might consume $O_3$ through the following reaction (Park, 1977):

$$O_3 + HCl \rightarrow O + O_2 + HCl \quad [1]$$

due to the above quenching, net $O_3$ levels were relatively low in early 2019 and before. In the absence of HCl emissions post ban, the ozone levels are building up. I would like to mention that in the year 2018, hundreds of tyre oil units were operated illegally in northern Delhi which were sealed. The pyrolysis oil which is used as a substitute for furnace oil or industrial diesel in heavy industries such as construction heating, cement factory, boiler factory etc. is a strong source of HCl on burning. Sealing such units might also be a reason of less ozone destruction resulting in higher levels of ozone in the air.

In addition, during COVID-19 lockdown, NO emissions are very less due to shut down of industries, flights, automobiles, brick kilns etc. As we know that similar to HCl, the NO also destructs ozone:

$$O_3 + NO \rightarrow O_2 + NO_2 \quad [2]$$

There are no prevalent sources of NO at present and hence, the destruction of ozone is lesser as compared to pre-COVID-19 scenario. Hence, the present limited HCl/Cl₂ and NO atmospheric conditions are responsible for building up of $O_3$ levels in the NCR-Delhi and such urban locations. The rural areas have more NO₂ than NO. Hence, more ozone is observed in rural areas due to lesser
NO. The fresh burning of fossil fuels is a major source of NO which is absent in rural areas and now such sources are absent in cities too due to lockdown making ozone levels in Delhi air similar to rural areas. However, another but smaller possibility of contribution of ozone through increased use of sanitizers which is a source of VOCs, cannot be ignored.

Reference:

Park C. 1977. Reaction rates for \( \text{O}_3 + \text{HCl} \rightarrow \text{O} + \text{O}_2 + \text{HCl} \), \( \text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2 \), \( \text{HCl} + \text{O} \rightarrow \text{OH} + \text{Cl} \), The journal of Physical Chemistry, 81, pp 499.

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Prof. U C Kulshrestha
JNU ENVIS RP Coordinator

Healing Impact of the Montreal Protocol*

Chlorine Concentrations Without Controls
Chlorine Concentrations with 1996 Phaseout

*on Chlorine Content of the Stratosphere  Source: EPA.gov
Crop Residue Burning in Northwestern India: Need for Alternative Solutions

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Abstract
As the degrading air quality during the onset of winters in north India is gaining attention of environmentalists for the past few years, crop rotation and residue burning have been found to be a leading challenge to tackle air pollution. Reduction of open burning may be the single largest and most cost effective mitigation options for health, food security and climate change. Farmers, on the other hand, have their own limitations. Thus, despite having a plethora of technologies for the crop residue management, their effectiveness is restricted due to the lack of awareness in the farmer’s community and further. Considering the extent of the air pollution problem from crop residue burning, there is a need to promote crop residue management machineries through comprehensive approaches. There is a need to generate shift in the mindset of the farmers and share best practices by the concerned authorities.

1. Introduction
Providing employment opportunities to close to half of the Indian population, agriculture has been the mainstay of the Indian economy and contributes around 17% to the national GDP. However, the manner in which it is practiced in some parts of the country has called for serious introspection. From the slash-and-burn agriculture in the northeast to soil salinization in the northwest, the different modes of agriculture have brought into limelight fundamental questions about the sustainability of agricultural production. Very recently, crop residue burning is also added to this list. Although the problem is not new, it has started hogging the limelight for the past few years. The crop residue burning is not just limited to crop productivity but is intertwined with the regional air pollution problem including severe impact over the National Capital Region (NCR).
Given the agro-climatic diversity of India, the generation of crop residues encompasses a whole gamut of crops such as rice, wheat, maize, jute, cotton, sugarcane, etc., in varying quantities. In an elaborated work Jain et al. (2014) have reported that out of the total 620Mt crop residue generated from foodgrains in India (Figure 1), rice contributes to a maximum of about 192Mt followed by wheat of about 120Mt annually. Most of such remains are cleared through on-field burning. Rice and wheat system alone, accounted for more than 60% crop residue burning in India. According to estimates in the year 2000, out of total dry residues generated from rice and wheat crops in India, nearly 25% are disposed of through an open field burning (Gupta et al., 2004). A study in 2008-09 has shown that about 132Mt crop residues were burned in the open field, where U.P and Punjab were among the top (Jain et al., 2014). The study has revealed that crop residue burning has caused emission of a large amount of pollutants such as CO₂, CO, CH₄, NOₓ, SO₂, Black Carbon, PAH, PM₂.₅ etc. (Badarinath et al., 2006; Sahai et al., 2007; Zhang et al., 2011). These emissions do not concentrate on that specific site, rather its impacts spill over all the adjoining areas and NCR with the harmful air pollutants. For the past few years, the Northwestern part of the country has been affected the most and its hazardous impact on the onset of winters has triggered a new debate among the atmospheric researchers. A sudden increase in the level of particulate matter and other harmful gases during the months of October and November has not only affected the daily life of people but also led to the severe health implications.

2. Cropping Patterns and Meteorology

Cropping patterns in the Indian subcontinent are majorly dependent on the summer monsoon. The growing season of Kharif crop, in the months of June to September, coincides with the southwest monsoon and plays a critical role in the food grain production. In the northern part of India these crops mainly include rice, maize and pulses. Kharif crop accounts for up to 50% of food grain and up to 65% of oilseed production in the country (Kumar et al., 2004). The growing season of Rabi crop starts after the summer monsoon from the months of October-November and continues until early summer i.e. months of March-April. The retreating southwest

![Figure 1. Production of foodgrains and generated residues annually (Jain et al., 2014).](image-url)
monsoon ends up storing ample amount of moisture content in the soil for the later sown Rabi crop (Prasanna, 2014). However, North-eastern (winter) monsoon provides rainfall for the rainfed Rabi crops in the southern part of India mainly Andhra Pradesh and Tamil Nadu. Thus, in the Northern part, summer monsoon is critical to the crop production. For Kharif crops production is highly dependent on the day-to-day variation in rainfall and precipitation at the end of summer monsoon decides the production of Rabi crops (Revadekar and Preethi, 2012). Due to the recent shift in the Indian monsoon patterns from past decades, reduction in rainfall in some areas and excessive rainfall in other areas have drastically affected the food grain production.

3. Crop Residue Burning States in India

The occurrence of smog over NCR after the harvesting period in the northwestern part of India, clearly traced its link with heavy biomass burning in the region (Ravindra et al., 2019). Studies have shown that the burning of crop residues, generated from the rice-wheat systems of western U.P., Haryana and Punjab, significantly contribute to the severe smog conditions in the region. Since the introduction of green revolution in India through the introduction of High Yielding Varieties (HYVs), particularly in the Northwestern regions, the cropping pattern has grossly distorted. On the one hand, it has pulled us out from the abyss of the agrarian distress by boosting the production of food grains, but conversely it has led to distortions in cropping patterns. From Figure 2, it is clear that the Northwestern part of India accounts for about 41% of rice production showing Punjab as the largest producer (28%) followed by Haryana (7%) and U.P.(6%) in this region. Similarly, for wheat production again the Punjab remains as the largest producer (37%) followed by Haryana (25%) and U.P. (6%), collectively accounting for 68% of total production (Pattanayak, 2016). In the Indo-Gangetic Plain, about 12 million hectare area is under the rice and wheat crop system. However, the northwestern part accounts for up to 75% cultivation area under this combine harvesting (Ladha et al., 2003). Due to the mechanized harvesting of the rice an enormous amount of crop residue is generated. Most of the residue thus accumulated after the reaping of the harvest is disposed of by setting the straws to fire in the fields. According to a recent estimate, about 85-90% of the paddy straw is burnt in the fields in Punjab alone. The similar treatment is meted to the wheat straw at the end of the Rabi season.
4. Reasons of Crop Residue Burning

The genesis of the stubble burning problem could be traced in the early 1980s, when farmers started switching to the mechanical harvesters. Cropping pattern of the rice-wheat system is such that it gives a very short span of time of about 10 to 15 days for preparing the field for the next crop. In a very short duration it becomes very difficult for farmers to extract all the straw left after harvesting of the previous crop. Also, the mechanized harvester cuts, threshes and cleans rice from the ripe paddy fields in no matter of time and saves days of manual labour. However, as opposed to manual harvesting, mechanized harvesters skim only the upper part of the plant and leave the stubble of 10 to 30 cm, depending upon the crop type. In case of paddy, it leaves up to 80% of the plant (six to eight inches) on the field (CSE, 2017). Further, the use of labour for stubble extraction is very expensive and not a feasible option for the small farmers.

So the burning of stubble becomes an easier option for the farmers. Unlike wheat residues, which can be used for animal fodder, rice straw has very high silica content which is not digestible for animals. Only the Basmati variety of rice has low silica content, but it is growing in smaller areas. Low economic cost of these residues and high processing price further reduces its value for farmers. Thus, burning of residues saves time, labour and money.

5. Crop Residue Management Alternatives

As mentioned in earlier sections, it is very clear from the facts that the rice-wheat system generates huge amounts of crop residues, the majority of which is concentrated in the Northwest region of India and a major cause of degrading air quality in NCR (Ravindra et al., 2019). Due to the high siliceous content of rice straw, its disposal is a serious concern (Bisen and Rahangdale, 2018). Where the residues of other cereals including wheat can be used
as cattle food and fodder, rice straw has very less use for farmers and cannot even be utilized in the roofing of houses. Despite almost equal production of crop output and residues, later has very little or no economic value for the farmers (CSE, 2017). The high cost of processing and lack of proper technology for recycling further discourage them. But if taken proper action, these residues can act as raw material for various products.

**Bio-refineries:** Biorefineries offer an effective solution to the productive disposal of organic wastes such as crop residues thereby resolving the intractable problems of waste management and GHGs emissions. As far as the latter is concerned, the use of crop residues in a biorefinery cuts down the potential GHG emissions by as much as 50% and also eats into the fossil fuel demand (Cherubini and Ulgiati, 2010). The organic wastes of various hues can be successfully utilized through this process. The Biomass wastes are converted into either gaseous or liquid fuels through the application of specific enzymatic/chemical reactions. The primary products obtained through this action includes paper-pulp, adhesives, solvents, resins, acetates, laminates, flavour chemicals, undigested sugars, activated carbon, fuel enhancers, etc. In lieu of the observations made so far it may be safely inferred that the establishment of biorefineries offer an effective solution for alternative energy in rural India, where a large amount of organic waste can be used for the purpose (Kulshrestha., 2015).

**Biogas Plant:** Crop residues generated from farming, are considered as one of the major unexploited energy potential which could be harnessed for methane (CH₄) rich biogas production through anaerobic digestion (Nordberg et al., 1998). Simultaneously in the process, the retainment and availability of the carbon and nitrogen of the residues would be increased due to reduced emissions to the air. Biogas is a combustible gas made up of 60% of CH₄ and 40% of CO₂ with a small percentage of other gases such as NH₃, NO₂, and H₂S. It is produced by the anaerobic fermentation of plant leaves, husk, straw, organic wastes, etc. Biogas can be combusted directly as a source of heat for cooking or can be used with an internal combustion engine for mechanical and electrical applications. Domestic or community based biogas plants are now effectively operating in various countries over the past couple of decades.

**Incinerators:** This is the preferred technique for waste management, particularly in developed countries. It reduces the waste volume by 90% at 900-1000 °C. Incineration offers environment friendly technique with very less emission free from offensive odours and gases. The waste heat from incineration can be utilized for supplementing electricity generation for domestic heating etc. The only drawback is that the technique is costly at present, requiring expensive equipments.

**Composting:** A complex interaction between microorganisms and organic waste under specific conditions. Three different types of microorganisms involved in the breakdown of organic wastes in composting include Actinomycetes (fungi, fungi and bacteria. Only pure biodegradable organic wastes such as crop residues, garden waste, wood chips, and
to some extent paper often collected and piled up in the pits, are suitable for producing good-quality compost. Breakdown of organic wastes under aerobic condition produces CO₂, ammonia, water, heat and humus (a dark amorphous product), the relatively stable organic end-product. Residue of paddy crop from one hectare farmland generates about three tons of manure, rich in nutrients. The nutritional value of the compost can be fortified using indigenous sources of low grade rock phosphate to make it value added compost with 1.5 % N, 2.3 % P₂O₅ and 2.5 % K₂O (Sidhu et al., 2005).

Livestock Feed: Traditionally, the crop residues in India are put to good use as animal feed with requisite addition of supplementary nutrients. However, crop residues by virtue of being unpalatable and low in digestibility are ill suited to form a sole ration for livestock. The rice straw because of its high silica content is considered a poor feed for animals. What sets it apart from other straws is not just higher content of silica (12-16 vs. 3-5%) but also lower levels of lignin (6-7 vs. 10-12%). The nutritional value of rice straw can be upgraded by different methods. In order to enhance the nutritive value of rice straw, physical, chemical and biological treatments are used in order to weaken and break down the lignocellulosic bonds. To complete the nutritional requirements of animals, the residues need processing and enriching with urea and molasses, and supplementing with green foders (leguminous/non-leguminous).

Surface Mulch: Retention of crop residues on the soil surface could be a better option for the soil conservation, also known as mulching. It can avoid water losses from evaporation and helps in soil nutrient enrichment. It suppresses weed growth and maintains soil health by increasing microbial population, which produces organic matter to the soil. Mulching of rice husk has shown 13 to 21% higher grain yield (Chakraborty et al., 2010). In this context, the recent introduction of The Happy Seeder, a machine developed by the Punjab Agriculture University in collaboration with Australian scientist five years ago, is very appropriate. The Happy Seeder drills the wheat seeds in the soil through the residues. It has been shown to reduce field operational costs marginally and maintain the wheat yield.

Other alternatives: Crop residues can also be used as raw material for various purposes such as power generation, ethanol production, rough paper and packaging material, for feed bricks making, handicrafts, mushroom cultivation and so on. For the utilization of all these alternatives, there is an urgent need to promote farmers for its collection through the government support and awareness programs.

6. Steps Taken to Combat the Problem

In response to alarming levels of air pollution in whole Northwestern India and NCR, there are several steps have been taken by the government in recent years. In 2015, National Green Tribunal (NGT) directed Punjab and Haryana to come out with an action plan to combat the recurring problem of pollution. Consequently, the state government has declared burning of paddy residue in the fields illegal and any farmer resorting to it is liable to action. But no further action was taken in this regard. Farmers have clearly expressed their
inability to avoid crop residue burning in the absence of any active government support. In this regard, Environment Pollution (Prevention and Control) Authority (EPCA committee for NCR) has actively worked to monitor the stubble burning status in neighbouring states to tackle the post-monsoon air pollution in NCR. In 2020, EPCA in collaboration with the central government has started an early review of the steps taken by the states to curb farm fires in view of COVID-19 pandemic. Punjab and Hayana have initiated projects on biomass based power plants and bio-ethanol projects. Haryana has already started hiring services of machineries to the farmers through mobile app and found encouraging outcomes.

7. Recommendations
Considering the extent of the air pollution problem from crop residue burning, there is a need to promote crop residue management machineries. For this, following points can be recommended-

• Local Authorities should discourage crop residue burning through awareness programs by the way of training, demonstrations and capacity building.

• There is a need for deeper understanding through research on economic viabilities and trade-off of alternative use of crop residues.

• More Custom hiring centers may be promoted for easy reach of costly equipment (which minimizes the stubble in the field) for small and marginal farmers at village level.

• Encourage women, small and landless farmers, which can enhance income and nutrition security through the adoption of various residue management operations.

• There is a need to draw the farmer’s attention before burning season in the months of July and August or February and March rather focusing after burning incidents so that they get enough time to think about alternative solutions.

References


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Major Impacts of Crop Residue Burning

Dr Manisha Mishra
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The burning of crop residues, generated from the rice-wheat systems of western U.P., Haryana and Punjab, significantly contribute to the severe smog conditions in the National Capital Region (NCR). Lower boundary layer in the post-monsoon months coincides with a significant increase in the gaseous and particulate pollutants from residue burning, which causes severe health hazards in addition to degrading soil quality. The major impacts of crop residue burning have been described below-

Air Pollution: Absorption of shortwave radiation during the crop burning period in any region gets significantly increased due to the emission of pollutants like Black carbon, SO$_2$, NO$_2$, CO, etc. (Rani Sharma et al., 2010; Ahmed et al., 2015; Mishra and Kulshrestha, 2017). The emission of GHGs and Particulate Matter from the crop residue burning produces a remarkable short-term impact on the local and regional weather patterns by altering the radiation budget (Ramanathan et al., 2001; Badarinath et al., 2009; Acharya et al., 2016). Exploring the global emissions from the burning of a wide variety of biomass, during the IGBP, it has been reported that after the forest fires, agricultural residue is the major source of CO$_2$ emission and contribute about 25% of the total biomass burning around the world (Chang and Song, 2010). Biomass burning emits significant quantity of the GHGs (CH$_4$, CO$_2$, N$_2$O), fine aerosols (PM$_{10}$ and PM$_{2.5}$), Smoke and other harmful gases such as SO$_2$, NO$_2$, NH$_3$, VOCs as shown in Table 1. Studies have revealed that incomplete combustion of biomass is the largest emitter of harmful particles like soot, PAHs etc., having a carcinogenic effect on human beings (Lamarque et al., 2010).

The burning of agricultural residues results in the release of different elements in their gaseous form. For instance, upon burning a unit amount of rice straw, the carbon present is released as CO$_2$, CO and CH$_4$ in the fraction of 70%, 7% and 0.66% respectively. Likewise, the Nitrogen constituent of the rice straw is emitted as NO$_x$ and N$_2$O in the fraction of 20% and 2.1% respectively. The Sulphur component, meanwhile, is emitted as SO$_x$ in the fraction of 17% (Jain et al., 2014). Taken cumulatively, the emissions caused by the burning of rice straws (40%) outstrip those caused by wheat (22%) and sugarcane (20%). The rice straw burning leads to greater emissions as compared to that of wheat straw burning has been reinforced in a study by Badarinath et al. (2006).
TABLE 1. Emission of air pollutants in India from crop residue burning in 2008-09 (Jain et al., 2014).

*NMVOC = Non-methyl volatile organic carbon, TPM = Total Particulate Matter, BC = Black carbon.

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<th>Pollutants</th>
<th>Emission (in Gg/yr)</th>
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<td>CO₂</td>
<td>149241</td>
<td>NH₃</td>
<td>128</td>
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<tr>
<td>CO</td>
<td>9063</td>
<td>HCN</td>
<td>15</td>
</tr>
<tr>
<td>NOₓ</td>
<td>7</td>
<td>PAH</td>
<td>2</td>
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<tr>
<td>NMVOC</td>
<td>39</td>
<td>PM₂.⁵⁺</td>
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<td>MVOC</td>
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Regarding wheat straw burning, Sahai et al. (2007) have estimated the magnitude of wheat straw emissions from agricultural fields in Pant Nagar, Uttar Pradesh. In a later study, Sahai et al. have estimated that burning of 63 Mt of crop residue emitted 4.86 Mt of CO₂ equivalents of GHGs, 3.4 Mt of CO and 0.14 Mt of NOₓ (Sahai et al., 2011).

Effect on soils: Researches from various studies have shown that crop residue burning may seem to have the short-term benefit to the farmers, but there is a slow and steady reduction occurs in soil health which eventually leads to the loss of nutrients and productivity (Mandal., 2004; Israelsen, 2015). It includes significant reduction in Carbon and Nitrogen pools. In situ burning readily assimilates the carbon and nitrogen sources for microbes and decreases the soil ammonium, potassium and phosphorus levels, which are essential as soil macronutrients. It has been estimated that burning can lead up to 80% of N, 4-60% of S, 25% of P and 21% of K losses leading to significant increase of air pollutants and reduction in soil nutrients (Lefroy et al., 1994; Ponnamperuma, 1984). Burning of residues can emit up to 13t/ha. CO₂ leaving the soil deprived of organic matter (Mandal et al., 2004). It has also been reported that burning of 10t/ha. removes about 730Kg of NPK from soil, losing the most critical factor of soil health (Gupta et al., 2002). Such type of soil degradation is most threatening for the rice-wheat sustainability (Timsina and Connor, 2001).

Health Implications: Emissions from the burning of agricultural biomass residue have been identified as a serious health hazard. Studies show that various types of environmental pollution contribute about 9 million mortality per year around the world. As per GBD reports, air pollution alone causes 6.5 million early mortality per year. Crop residue burning has been observed as a major regional source emitting enormous amount of pollution and causes exposure to very high levels of PM concentration in the immediate vicinity. This can cause chronic bronchitis,
aggravate asthma and decrease lung functions (Kumar et al., 2015). Smoke from burning also affects the brain and nervous system. Emission of harmful chemicals from biomass burning such as polycyclic aromatic hydrocarbons (PAH’s), polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDFs) also known as dioxins, are known for their potential carcinogenic properties (Gadde et al., 2009). Stubble burning also causes O3 pollution, which on mixing with smoke pollutants in sunlight, forms Peroxyacetyl Nitrate (PAN). PAN is one of the potential compounds of photochemical smog, which is an eye and throat irritant. A survey by Kumar et al. (2015) has shown that crop residue burning in a rural area of Punjab causes higher occurrence of respiratory diseases for local people. Such results were very well coinciding with the high pollutant levels, particularly during autumn and winter months in two consecutive years (2007-08).

References


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Graded Response Action Plan
Yogendra Singh,
Final Year Ph.D Scholar,
School of Environmental Sciences, Jawaharlal Nehru University, New Delhi - 110 067

What is the Graded Response Action Plan (GRAP)?

The Graded Response Action Plan (GRAP) is a recently introduced quick responding action plan, against increasing air pollution in National Capital region (NCR) Delhi, which is directed by the Environment Pollution Control Authority (EPCA). The GRAP has been notified by the government for Delhi-NCR in 2018. The GRAP task force ensures the enforcement of Graded Response Action Plan (GRAP) in NCR as per the pollution levels. The task force of GRAP consists of expert members from various agencies such as Central Pollution Control Board (CPCB), Representatives from pollution boards of the adjoining states, Greater Noida Industrial Development Authority, India Meteorological Department, Ministry of Environment, Forest and Climate Change etc. The task Force on Graded Response Action Plan (GRAP) holds meetings and recommends actions to be implemented in the field. The directions of the Task Force are given to the civic agencies such as urban development departments, transport department, Pollution Control Committee of Delhi (DPCC) and the traffic police which enforce these immediately in the field.

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Mr. Yogendra Singh

Link to GRAP paper: https://www.cwejournal.org/pdf/vol15no1/Vol15_No1_p_29-41.pdf
Isolation and Characterization of Bioaerosols in Different Size Ranges at Selected Locations of Delhi City

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Abstract

Pandemic outbreak of flu due to influenza A H1N1 virus in 2009 and Covid 2019 alarmed us about the importance of bioaerosol research. Hence characterization i.e. identification and quantification of different airborne microorganisms in various indoor and outdoor environments is necessary to identify the associated risks and to establish exposure threshold. In this study ambient levels of bioaerosol were measured at four different sites of New Delhi city. The sampling was carried out in monsoon season, September 2019. Most of the fungal bioaerosols identified are associated with immunotoxic diseases such as allergic asthma, exert type I hypersensitivity reactions, allergic fungal rhino sinusitis (AFRS), allergic Broncho pulmonary aspergillosis (ABPA), allergic Broncho pulmonary aspergillosis (ABPA), hypersensitivity pneumonitis (HP), allergic rhinitis, Chromoblastomycosis and many more diseases. The airborne fungi can be toxicogenic, allergenic, infectious and also sometimes harmless.

1. Introduction

As a class of airborne pollutants “Bioaerosols” are particulate matter usually associated with compounds of biological origin (Heikkinnen et al. 2005). This definition includes all pathogenic or non-pathogenic, live or dead fungi and bacteria, Fungal spores, bacterial endotoxins, mycotoxins, peptidoglycans, β (1, 3) Beta (1→3) glucans polysaccharides found in the cell walls of certain fungi, particularly Aspergillus species, viruses, high molecular weight allergens, pollens, by product of microbial metabolism present as particulate, liquid or volatile organic compound etc. (Douwes et al., 2003). The main pathway for transmission of microorganisms to humans are direct exposure to contaminate sources through skin, mouse membrane, inhalation, ingestion and through hands (Mohr, 2002). The inhalable fraction of bioaerosol are most important because these size particles can reach to the deeper layers of respiratory system and evaluated as air pollutants which leads to the decreasing functioning of the lungs and cause different respiratory symptoms like cough, shortness of breath, wheezing, asthma attack, Chronic obstructive pulmonary diseases, Cardiovascular diseases and lung cancer (WHO, 2002). Fungi exposure can indeed cause adverse health effects, including infections, hypersensitivity disorders,
and toxic/irritant effects from their by-products. Less clearly established are a variety of constitutional symptoms resulting from indoor mold exposure, including fatigue, nausea, cognitive dysfunction, and immune dysfunction, as well as putative syndromes such as "toxic mold syndrome" and "mold-induced immune dysregulation" (Bush RK et al., 2006).

1.1. What are the Known Health Effects from Fungal Exposure?

Known health effects from fungal exposure include infection, illness from ingestion of mycotoxins, and various hypersensitivity disorders. The majority of fungi are not pathogenic to immune competent humans. However, certain fungi are capable of infecting otherwise healthy individuals, including *Dermatophytes*, *Trichophyton*, *Epidermophyton*, *Microsporum*, *Histoplasma*, *Blastomyces*, *Cryptococcus*, *Coccidioides*, and *Paracoccidioides*.

Immune compromised individuals are at risk for opportunistic infections with fungi, such as *Candida*, *Aspergillus*, *Fusarium*, or *Mucor*. Those most often affected include patients with advanced acquired human immunodeficiency virus (HIV) syndrome, those on immunosuppressant therapy or cancer chemotherapy, neutropenic patients, or patients with poorly controlled diabetes mellitus. "All fungi are capable of producing toxins (mycotoxins) and more than 300 mycotoxins have been identified" (Rylander R., 1997). Most of the descriptions of mycotoxicosis in humans are derived from the ingestion of moldy foods (Hardin BD et al., 2003).

There were two main toxin in fungi which identified in four sites (Aflatoxins and Ochratoxin A) Aflatoxins: is mainly produced by *Aspergillus flavus* (Searl, A. 2008) and by many species of *Aspergillus*, Aflatoxins is one of the most carcinogenic substances known. Aflatoxins B1 is most toxic which is mainly released by *A.Flavus* & *A. Parasiticus*.

Ochratoxin A, a toxin produced by various species of *Aspergillus*, *Penicillium*, *A.carbinicouse* which is potentially considered cancerogenic to humans and has been shown to be a weekly mutagenic, possibly by induction of oxidative DNA damage.

Aflatoxins, produced by *Aspergillus* species, are also of medical significance. Foods for consumption by humans and animal feeds are monitored for aflatoxin contamination as part of standard food safety practices in most developed countries (Cigić IK. et al., 2009).

There are several defined disorders that involve hypersensitivity reactions to fungi, including asthma and allergic rhinitis, hypersensitivity pneumonitis (HP), allergic Bronchopulmonary aspergillosis (ABPA), and allergic fungal rhinosinusitis (AFRS).

Asthma: exposure to outdoor fungi, particularly *Alternaria*, are associated with asthma (Bush RK et al., 2004) (Salo PM et al., 2006).

Allergic rhinitis: Allergic rhinitis symptoms have correlated with positive skin tests and positive in vitro tests to the common outdoor molds, *Alternaria and Cladosporium*. (Jaakkola MS et al., 2013).
Hypersensitivity pneumonitis sensitivity to fungal antigens is among the most common cause of hypersensitivity pneumonitis (HP) (Hogan MB et al., 1996). Allergic Bronchopulmonary aspergillosis (ABPA) is a hypersensitivity reaction to Aspergillus in the lower airways (Levy MB et al., 2004).

2. **Sampling Site:** Sampling was done at four different sites in Delhi. The four sites are as mentioned below in Table 1.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Sampling Site</th>
<th>Site Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JNU health center</td>
<td>Institutional camp</td>
</tr>
<tr>
<td>2</td>
<td>Munrika Family houses</td>
<td>Residential Area</td>
</tr>
<tr>
<td>3</td>
<td>Sarojini Nagar Market</td>
<td>Commercial Area</td>
</tr>
<tr>
<td>4</td>
<td>Okhla Phase One</td>
<td>Industrial Area</td>
</tr>
</tbody>
</table>

Figure 1. Map showing the four different sampling sites

3. **Methodology**

3.1. **Bioaerosol Sampling**

For fungal bioaerosol sampling, an Anderson six stage viable cascade impactor manufactured by Tisch Environment USA, used for monitoring the bioaerosols over the selected sampling sites. The sampling was carried out during the monsoon season for about 5 min at each site. The sampler was kept at 1-2 m above the ground to parallel the human breathing zone (Huang, 2002). The locations and characteristics of sites have been given in table 1 and shown in Fig. 1.
cascade impactor consists of a stack of impaction stages. Each stage involves 400 nozzles. The air stream passes through the nozzles and particles larger than a particular aerodynamic size would be impacted onto a collection agar media while smaller particles get through nozzles may take the form of holes. The target may consist of a growth media (agar) contained in petri dishes. Each following stage collects smaller particles. Although culture is the commonly used method to identify a fungus in the environment, DNA sequencing is an evolving approach.

3.2. Meteorological Parameters Monitoring

Temperature and relative humidity play a major role in bioaerosol levels in order to measure the meteorological parameters such as temperature, relative humidity (RH), and wind velocity, Enviro meter (Fisher Scientific) was used. The present study was carried out during the monsoon period with optimum temperature range (27-34 °C) and relative humidity. Temperature and higher relative humidity (61-69%), favor microbial growth.

In order to ensure that our work environment and processes are completely clean and devoid of any kind of microbial contaminants, laboratory media blanks were prepared, unexposed fresh media samples were incubated in the same manner as sampling media but not taken into the field. As per standard procedure, the fungal sample needs to be incubated at 25°C for three to five days. The macroscopically visible growth of fungi on a solid medium is enumerated by using this formula.

\[
\text{Bio aerosol conc. (CFU/ m}^3\text{) = No. of colonies / Flow rate x Sampling duration (min)}
\]

\[
\text{Flow rate = 28 lit/min}
\]

4. Results and Discussions

In this study, the Fig.2 represents the stage-wise sampling at four different locations in Delhi. The total coloni forming units (CFUs) were observed as (100001 CFU/meter cubic). The highest CFU were observed at JNU health center (33928 CFU/meter cubic) and minimum were at Sarojini Nagar (20179 CFU/meter cubic). It can be inferred from Fig. 2 that, there is an increasing trend in the concentration of fungal bioaerosol from stages (1- 4) with a further decreasing trend from stage (4 - 6) which was found to be synonymous to the fungal bioaerosol study carried out at the university campus and sewage treatment plant in Delhi by Srivastava et al. (2012) and Maharia and Srivastava (2015) respectively. In all four sites the highest concentration of fungus is found in stage 4 (size range 2.1 to 3.3 µm) and lowest concentration in stage 5 & 6 (size range 0.6 to 1.1 µm). The very typical pattern observed at four locations depicts that fungal species consist of nearly analogous diameter as that of stage 4 which is equivalent to the secondary
bronchi of the lungs in human beings. This reveals that the majority of the immunotoxic and allergic fungi found at this stage are mostly prone to affect the secondary bronchi in human lungs when inhaled. The almost similar result was found to be depicted in the size segregated fungal study carried out in a landfill site in Delhi by Agarwal et al. (2016) wherein concentration peak was observed in the size range of 2.1 to 5.8 µm (that is synonymous to stages 2 to 4). The observed fungal species were identified on the basis of their morphological features. As shown in Table.2, the most dominant 13 species were found out at four sampling sites in Delhi in which 9 species are allergic in nature mostly, 3 are found to be harmless and 1 is immunotoxic in nature. Presence of Aspergillus sp. in maximum at almost four sites represents an allergic environment.

Figure 2. Graph shows stage wise sampling at four different locations in Delhi
Figure 3. Graph shows site wise fungal bioaerosol concentration at four sampling sites.

Figure 4: Graph shows stage wise fungal bioaerosol concentration at four sampling sites. Which shows highest concentration at stages 3 and 4.
### TABLE 2: Observed fungi bioaerosols monitored at four different sites in Delhi

<table>
<thead>
<tr>
<th>No.</th>
<th>Fungi Name</th>
<th>Descriptions</th>
<th>Pictures</th>
<th>The study sites</th>
<th>Health Effects</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Aspergillus niger</em></td>
<td>Color: Black; Kingdom: Fungi; Class: Eurotiomycetes; Scientific name: Aspergillus niger; Family: Trichocomaceae; Higher classification: Aspergillus</td>
<td><img src="image1.png" alt="Picture" /></td>
<td>All four sites</td>
<td>Allergic</td>
<td>Palma et al., 2017; Grigosecvet al., 2012</td>
</tr>
<tr>
<td>2</td>
<td><em>Aspergillus flavus</em></td>
<td>Color: Light green; Kingdom: Fungi; Class: Eurotiomycetes; Order: Eurotiomycetes; Family: Trichocomaceae; Genus: Aspergillus</td>
<td><img src="image2.png" alt="Picture" /></td>
<td>All four sites</td>
<td>Allergic</td>
<td>Parsinagama et al., 2003; Aoki et al., 2011</td>
</tr>
<tr>
<td>3</td>
<td><em>Aspergillus parasiticus</em></td>
<td>Color: Dark green; Kingdom: Fungi; Class: Eurotiomycetes; Order: Eurotiomycetes; Family: Trichocomaceae; Genus: Aspergillus; Species: A. parasiticus</td>
<td><img src="image3.png" alt="Picture" /></td>
<td>All four sites</td>
<td>Allergic</td>
<td>Rascon et al., 2005</td>
</tr>
<tr>
<td>4</td>
<td><em>Aspergillus fumigatus</em></td>
<td>Kingdom: Fungi; Class: Eurotiomycetes; Order: Eurotiomycetes; Family: Trichocomaceae; Genus: Aspergillus; Species: A. fumigatus</td>
<td><img src="image4.png" alt="Picture" /></td>
<td>All four sites</td>
<td>Allergic</td>
<td>Flammé et al., 2002; Paracceira et al., 2006</td>
</tr>
<tr>
<td>5</td>
<td><em>Aspergillus carbonarius</em></td>
<td>Dark brown to black; Kingdom: Fungi; Class: Eurotiomycetes; Order: Eurotiomycetes; Family: Trichocomaceae; Genus: Aspergillus; Species: A. carbonarius</td>
<td><img src="image5.png" alt="Picture" /></td>
<td>Municite</td>
<td>Allergic</td>
<td>Esteban et al., 2006</td>
</tr>
<tr>
<td>6</td>
<td><em>Aspergillus ostus</em></td>
<td>Color: Yellow with outer white; Kingdom: Fungi; Class: Eurotiomycetes; Order: Eurotiomycetes; Family: Trichocomaceae; Genus: Aspergillus; Species: A. ostus</td>
<td><img src="image6.png" alt="Picture" /></td>
<td>Municite</td>
<td>Allergic</td>
<td>Hodgson et al., 1985; Regula et al., 2005</td>
</tr>
<tr>
<td>7</td>
<td><em>Penicillium chrysogenum</em></td>
<td>Kingdom: Fungi; Division: Ascomycota; Class: Eurotiomycetes; Order: Eurotiomycetes; Family: Trichocomaceae; Genus: Penicillium</td>
<td><img src="image7.png" alt="Picture" /></td>
<td>Okhia phase 1</td>
<td>Harmless or not allergic</td>
<td>Szaposons et al., 2005</td>
</tr>
<tr>
<td>No.</td>
<td>Genus and Species</td>
<td>Kingdom: <strong>Fungi</strong></td>
<td>Division: <strong>Ascomycota</strong></td>
<td>Class: <strong>Eurotiales</strong></td>
<td>Order: <strong>Eurotiales</strong></td>
<td>Family: <strong>Trichocomaceae</strong></td>
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<tr>
<td>8</td>
<td><em>Penicillium</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><em>Penicillium</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td><em>Basidiomycetes</em></td>
<td>Growth is typically rapid, often up the side of the tube or plate, and colony colors are usually white, but they are sometimes cream to golden, orange, or slightly brownish on PDA.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td><em>Trichoderma</em></td>
<td>Color: Pink with white outer ring.</td>
<td>Kingdom: <strong>Fungi</strong></td>
<td>Division: <strong>Ascomycota</strong></td>
<td>Class: <strong>Sordariomycetes</strong></td>
<td>Order: <strong>Hypocreales</strong></td>
</tr>
<tr>
<td>12</td>
<td><em>Trichoderma</em></td>
<td>Color: yellow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td><em>Alternaria</em></td>
<td>Color: Dark green with black center and outer white circle.</td>
<td>Kingdom: <strong>Fungi</strong></td>
<td>Division: <strong>Ascomycota</strong></td>
<td>Class: <strong>Dothideomycetes</strong></td>
<td>Order: <strong>Pleosporales</strong></td>
</tr>
</tbody>
</table>
Figure 5 and 6: Shows the observed Aspergillus Species at four different sites in Delhi

Figure 7 and 8: shows the observed Ulocladium Species at four different sites in Delhi

Figure 9 and 10: shows the observed Penicillium notatum Species at four different sites in Delhi
5. Conclusion:

1. The study found 13 most dominant fungi colonies and identified on the basis of their morphological features as mentioned in the table 1 and other several references. The 13 dominantly observed fungal bioaerosol these nine mainly, Aspergillus Niger, Aspergillus flavus, Aspergillus parasiticus, Aspergillus fumigatus, Aspergillus carbonarius, Aspergillus ustus, Penicillium chrysogenum, Penicillium verrucosum, Trichoderma harzianum and only Alternaria fungi species observed is immunotoxic in nature.

2. It can be concluded from this study that the order of fungal bioaerosol concentration were as follows:

JNU health center > Okhla Phase 1 > Munirka Family Association > Sarojini Nagar Market. The maximum fungal bioaerosol concentration was found at JNU health center which is within the premises of the Jawaharlal Nehru University, New Delhi and minimum is found at Sarojini Nagar Market. In the monsoon season, highest fungal bioaerosol concentration was found in stage 4 and lowest concentration at stage 5 & 6. Stage 4 has a diameter range of (2.1–3.3 micrometer) which is considered as the secondary bronchi of the lungs in the human body. Hence, the presence of the majority of the immunotoxin and allergic fungi at stage 4 reveals when inhaled at these sites are affecting the pedestrians, workers in the industrial region and the residents in the family association of Munirka.

3. Among all the four sites, the highest concentration of fungi bioaerosol was found at stage 4 on all the three sites mainly JNU Health center, Munirka Family Association, Okhla Phase 1 whereas the highest concentration of fungi bioaerosol was observed in stage 3 at Sarojini Nagar Market. The stage 3 represents (3.3-4.7 micrometer) which will directly impact the trachea and primary bronchi.

References:


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Mitra Dehyar, M Sc student
Air Quality of JNU Campus: Continuous Short Measurements of PM\textsubscript{2.5} and PM\textsubscript{10} aerosols

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(umeshkulshrestha@gmail.com)

Introduction

Particulate matter (PM) in the ambient atmosphere are significant air contaminants owing to their impact on atmospheric radiative balance, local and regional ambient air quality, visibility, human health, ecosystem etc (IPCC, 2007). Ambient air quality of any region primarily depends on the prevailing anthropogenic activities and meteorological conditions. Air pollution has been a concern for landlocked megacities such as Delhi, where the polluted air comparatively does not get the chance to replace with the unpolluted air. Industrial activities, transport, road side construction and regional emission as well as long range sources contribute a very significant fraction to aerosol mass loading in the region (Sharma and Kulshrestha, 2014; Nagpure et al., 2013). Although, several measures such as introduction of compressed natural gas (CNG) in public transport, relocation of industries, introduction of metro transport etc have been taken to reduce the burden of pollutants, other factors responsible for the deterioration of ambient air quality of Delhi are domestic combustion of coal and biomass (Garg et al., 2006; Gurjar et al., 2004). Advection of air masses from arid and semi-arid regions of western India in summers, northern parts of India in winters and from marine regions in monsoons season imparts variability in the chemical composition and physical properties of PM over northern Indian.

Several studies have been done (Sharma and Vachaspati, 2016; Singh and Kulshrestha, 2020; 2016) in the past to evaluate ambient air quality and to estimate the emission of different pollutants from the sources. However, limited study on variability of PM has been reported near JNU. In the present study, variation in concentrations in PM\textsubscript{10} and PM\textsubscript{2.5} have been studied during November 2019 in the vicinity of JNU campus.

Methodology

Continuous measurements of PM\textsubscript{2.5} and PM\textsubscript{10} were made by using Fidas® Frog wireless handy sampler which was provided by MK Technology Pvt Ltd. New Delhi. The sampler sucks air at a flow rate of 1.4 LPM. It measures simultaneously the environmentally relevant mass fractions PM\textsubscript{1}, PM\textsubscript{2.5}, PM\textsubscript{4}, PM\textsubscript{10}, TSP as well as the particle number and the particle size distribution within the particle size range of 0.18–100 μm. The operator receives comprehensive information for evaluation and assessment of the fine dust pollution by providing fine dust values with high time resolution.
Results

Variation in concentration of PM$_{2.5}$ and PM$_{10}$

Fig. 2 shows the variation in concentration of PM$_{2.5}$ and PM$_{10}$ in JNU campus. It has been found that the highest concentration was near SSS-3 parking followed by Purvanchal bus stop. The highest concentration of PM at these sites might be due to vehicular exhaust. SSS-3 has influence of main parking of vehicles near schools while Purvanchal bus stop is the main bus terminal in the campus. Hence, the vehicular density is high near Purvanchal bus stop. At the Paschimabad and East gate, the concentration of PM is very low, may be due to very less vehicular activities occurring at both sites. The results shows the concentration of PM$_{2.5}$ and PM$_{10}$ was higher from the NAAQS standard at all the sites except Paschimabad and Purvanchal.

![Variation in concentration of PM$_{2.5}$ & PM$_{10}$](image)

*Fig. 2 Variation in concentration of PM$_{2.5}$ & PM$_{10}$. (Green line indicates NAAQS value of PM$_{10}$ while yellow dotted line indicates the NAAQS value of PM$_{2.5}$)*
References


Anshu Sharma, Ph D student.

PM$_{2.5}$ Pollution Map of JNU (For November 21, 2019).

Using Fidas® Frog wireless handy sampler (courtesy: M K Technology).
NCR Air Pollution: Source, morphology and elemental composition of aerosol particles

Anshu Sharma and U.C Kulshrestha

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Introduction

Atmospheric particles are ubiquitous in the troposphere and exert an important influence on the global climate and the environment. They affect climate through scattering, transmission, and absorption of solar radiation as well as by acting as cloud condensation nuclei for cloud formation. Delhi, one of the worst polluted mega cities of Asia and is also faced with a typical problem of desert aerosols every year during the pre-monsoon period i.e., April–June Kulshrestha and Sharma, 2015). These aerosols are brought by windblown dusts from the Thar Desert in Rajasthan. Consequently, the visibility is reduced and the local radiative forcing is significantly affected (Goyal and Sidhartha, 2003; Nagdeve, 2004; Srivastava et al., 2005; Gurjar et al., 2004). However, it is already known that the SPM in Delhi’s environment is not only contributed by vehicular and industrial activities but also significantly because of soil originated particles and re-suspended dust generated by strong winds and construction activities. The facts about air pollution in Delhi have been reported by Kulshrestha (2015).

Many studies have already been carried out to demonstrate and establish the relationship between the origin of the particles and potential adverse effects on human health. Some have been done using SEM-EDX techniques by the particle’s morphology and elemental composition (Umbrı et al. 1999; Chabas and Lefevre 2000; Ma et al. 2001; Bernabe and Carretero 2003; Liu et al. 2005). The elemental composition of atmospheric particles is some times more useful than their bulk elemental composition with a view to establish their origin and their potential effects on human health. Still, the studies on elemental composition of atmospheric particles are rather limited (Querol et al. 1999; Pina et al. 2000, 2002; Shi et al. 2003; Breed et al. 2002; Querol et al. 2002; Ekosse et al. 2004; Mathis et al. 2004; Suzuki 2006). In the present study, an application of SEM-EDX techniques for morphology and elemental composition of aerosols has been used. The results have been evaluated to understand the potential sources of air pollution.
Methodology

The sampling site Babarpur which is located in east Delhi has been chosen for this study. The samples were collected from about 15 m height from the ground, on the quartz filter using a handy sampler (APM 821, Envirotech model) and at an average flow rate of 1 LPM.

Results

Morphology of PM$_{2.5}$

SEM micrographs of PM2.5. (Fig.1) shows the different morphology, ultimately indicating their different source origin of atmospheric TSP.

At this urban site micrographs shows irregular, flaky, crystal, amorphous shaped aggregates and more roundish(soot) particles. Similar results were found by many co-workers at Delhi (Sonwani and Kulshrestha et al., 2018; Sharma et al., 2017; Kumar et al., 2014).

![Figure 1. Scanning electron microscopy images of PM$_{2.5}$.](image)

Elemental composition of PM2.5

Morphological analysis of PM2.5 through SEM imaging showed that the freshly emitted soot particles, cluster aggregates of soot, Fe-rich particles, the crystal of sulphate and nitrate are predominated at the site.

Results showed that they are emitted from several anthropogenic sources such as fossil fuels combustion, metal smelting, coal power plants, waste incineration and atmospheric long-range transport.

References


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Indoor Air Purification through Plants

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PhD Scholar,
School of Environmental Sciences, Jawaharlal Nehru University, New Delhi 110067 India

Plants make a great addition to the corner of a room be it our house, office or any built structure. People often buy house plants mostly for aesthetic reasons because of their pleasant appearance, overlooking some important benefits that come with them. It was estimated by WHO that 7 million people die from air pollution every year which accounts for 1 in 8 of total global deaths.¹ NASA launched a Clean Air study in 1989 to determine which household plants are best at purifying the air and research has shown that certain indoor plants act as a natural filter to indoor pollution by absorbing pollutants and converting them to harmless substances.² Common indoor plants may serve as a valuable weapon in the fight against rising levels of indoor air pollution and some of them can absorb up to 85% of potentially harmful gases, cleaning the air inside our homes, indoor public spaces and office buildings. They are inexpensive, easy to maintain and also.

References


Correlation between some components of interior plants and their efficiency to reduce formaldehyde, nitrogen and sulfur oxides from indoor air. Int Res J Plant Sci, 3(10), 222-229.

Cruz, M. D., Christensen, J. H., Thomsen, J. D., & Müller, R. (2014). Can ornamental potted plants remove volatile organic compounds from indoor air?—a review. Environmental Science and Pollution Research, 21(24), 13909-13928.
### TABLE 1: List of common indoor plants and the air pollutants they remove

<table>
<thead>
<tr>
<th>Indoor Plant</th>
<th>Common Name</th>
<th>Air Pollutants Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gerbera jamesonii</td>
<td>Gerbera Daisy</td>
<td>Benzene, formaldehyde, trichloroethylene</td>
</tr>
<tr>
<td>Chrysanthemum</td>
<td>Chrysanthas/Chrysanthems</td>
<td>Benzene, formaldehyde, xylene, ammonia</td>
</tr>
<tr>
<td>Scindapsus aureum</td>
<td>Money Plant/Golden Pothis/Devil’s Ivy</td>
<td>Benzene, formaldehyde, xylene</td>
</tr>
<tr>
<td>Chlorophytum comosum</td>
<td>Spider Plant</td>
<td>Benzene, formaldehyde, xylene, carbon monoxide, SOx</td>
</tr>
<tr>
<td>Hedera helix</td>
<td>English Ivy</td>
<td>Benzene, formaldehyde, trichloroethylene, carbon monoxide, particulate matter</td>
</tr>
<tr>
<td>Sansevieria trifasciata</td>
<td>Mother-in-law’s tongue</td>
<td>Benzene, formaldehyde, trichloroethylene, carbon dioxide</td>
</tr>
<tr>
<td>Dracaena marginata</td>
<td>Dragon plant</td>
<td>Formaldehyde, trichloroethylene, xylene</td>
</tr>
<tr>
<td>Nephrolepis exaltata</td>
<td>Boston fern</td>
<td>Formaldehyde, xylene, carbon monoxide</td>
</tr>
<tr>
<td>Spathiphyllum</td>
<td>Peace lily</td>
<td>Benzene, formaldehyde, trichloroethylene, xylene, toluene, NOx</td>
</tr>
<tr>
<td>Dypsis lutescens</td>
<td>Areca palm</td>
<td>Acetone, xylene, formaldehyde, toluene</td>
</tr>
<tr>
<td>Ficus elastica</td>
<td>Indian rubber plant</td>
<td>Carbon dioxide, formaldehyde, benzene, xylene.</td>
</tr>
<tr>
<td>Schefflera</td>
<td>Umbrella plant</td>
<td>Benzene, formaldehyde, toluene</td>
</tr>
<tr>
<td>Ficus benjamina</td>
<td>Weeping fig</td>
<td>Formaldehyde, xylene, toluene, NOx</td>
</tr>
<tr>
<td>Philodendron</td>
<td>Philodendron</td>
<td>Formaldehyde, benzene, carbon monoxide</td>
</tr>
<tr>
<td>Aloe vera</td>
<td>Aloe vera</td>
<td>Formaldehyde, benzene</td>
</tr>
</tbody>
</table>

Ankita Katoch, Ph D student
Atmospheric Mercury Measurements at Delhi

Sunaina and Umesh Kulshrestha

Atmospheric Chemistry and Climate Change Group, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi 110067 INDIA

The atmospheric mercury is one of the toxic air pollutants prevailing in the industrial areas and megacities due to increased coal combustion for meeting energy demands (Landis and Keeler 2002). Atmospheric mercury research in south Asia has been reviewed by Kumari et al (2014). The mercury has a strong tendency of bioaccumulation posing a threat to human health and environment. The mercury exists in three major forms in the atmosphere: particulate mercury, gaseous mercury and organic mercury. Sometimes due to global biogeochemical cycling through air and water and long-distance atmospheric transportation of mercury, regions with little or no mercury emissions (remote areas) may have high environmental mercury levels (Schroeder and Munthe 1998). Many studies have reported an association between particulate matter and adverse health effects on people. The exposure to high concentrations of particulate matter, especially fine particles, showed an increased risk of outbreaks of cancer, respiratory symptoms and mortality rates (Dockery and Pope 1994; Espinosa et al. 2001; Shah et al. 2006). Apart from the size and concentration, the toxicity and composition of particulates also severely affect human health. Kumari and Kulshrestha (2018) have reported particulate mercury at a rural site near Delhi.

This study reports mercury concentrations in rain water in Delhi region, India. The rainwater samples were collected during pre-monsoon and monsoon seasons at a residential site called Sitapuri which lies in South-West Delhi, India. The rain water samples were collected at the terrace of a building using bottle and funnel methods. The Elemental Hg was determined by using Differential Pulse Anodic Stripping Voltammetry through the standard addition methods. The average concentration of mercury was found to be 1.6 μg/l ± 1.28. The concentration range of mercury varied from 4.35 μg/l to 0.41 μg/l. In the pre-monsoon samples, Hg concentration was remarkably higher as compared to the monsoon samples. The results of the study indicated that the construction and domestic activities were among the major contributors of atmospheric mercury at the site. This study revealed that the wet deposition of mercury may affect the soils, vegetation, crops and water bodies etc.
References


Sunaina, Ph D student
HOLISTIC ENVIRONMENT

YO HO SEMINAR

Departmental Lecture Series

Topic: Environmental Toxicology and Sustainable Development

Speaker: Prof. Tanu Jindal,
Group Additional Pro Vice Chancellor (R&D)

Date: Tuesday,
3rd March, 2020
Venue: ADB hall, SES,
JNU

Highlights:
- Environment Toxicology
- Heavy metals and PoPs
- Soil and Water Pollutions
- Circular Economy and Sustainable Development

Director, Amity Institute Environmental Sciences
Director, Amity Institute Environmental Toxicology, Safety and Management
Director, Amity Institute of Water Technology and Management
Director, Amity Centre for Antarctic Research and Studies
Director, Amity Institute of Oceanography and Atmospheric Sciences
Advisor - Amity Institute of Marine Science and Technology
Amity University Uttar Pradesh, Noida INDIA

Prof. U C Kulshrestha, Dean SES & ENVIS Coordinator Welcoming the Guest Prof. Tanu Jindal
Lecture by Prof. Tanu Jindal
Lecture Attended by Faculty, Students of SES & JNU ENVIS
Vote of Thanks by Lead Mr. Monib from SES
HOLISTIC ENVIRONMENT

YO HO SEMINAR

Departmental Lecture Series

Topic: Surveillance and Diagnosis of Environmental Pollution-HealthClimate Interactions: Challenges and Way Forward

Speaker: Prof. Panuganti CS Devara,
Director, Amity School of Earth and Environmental Sciences, Manesar

Prof. (Dr.) Panuganti CS Devara is currently Director (ASEES, ACOAST and ACESH) at Amity University Haryana (AUH), Manesar-Gurugram, India. He is FELLOW of Royal Meteorological Society (RMeS), UK; PRESIDENT of Indian Aerosol Science and Technology Association (IASTA), India, and FELLOW of Asian Aerosol Research Assembly (AARA), Taiwan. He has rich experience, for more than 40 years, in the Active and Passive Optical and Radio Remote Sensing of the Atmosphere, Oceans, Weather and Climate. His areas of interest also include Environmental Pollution Monitoring, Diagnosis and Mitigation. He is an Expert Reviewer of IPCC, UNEP, NSF, EU Funding Agencies, and many leading Science Journals. He published, so far, more than 150 Research Papers in Refereed Journals, Proceedings and Text Book Chapters. He received several Awards including the recent "Eminent Scientist Award -2020", and Fellow & Member of several Scientific and Professional Bodies in India and abroad for his original contributions to the field of Physics, Chemistry and Dynamics.

Date: 4th March, 2020
Venue: ADB hall, SES, JNU

Highlights:
Pollution & Health Impacts
Pollution Forecast Modeling & Monitoring
Remote Sensing & LIDAR

Prof. U C Kulshrestha, Dean SES & ENVIS Coordinator
Welcoming the Guest

Lecture by Prof. Panuganti CS Devara

Snapshots of Presentation
Group Photo
Vote of Thanks by Mr. Yogendra
To,

If undelivered, please return to:

The Coordinator
JNU-ENVIS RP: Geodiversity & Impact on Environment
School of Environmental Sciences
Jawaharlal Nehru University, New Delhi – 110 067