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Special Issue

Aerosol and Air Pollution

From the Editor's Desk

Delhi, the sixth-most populated metropolis in the world, is one of the most heavily polluted cities in India. Environmental problems in Delhi are a threat to the well-being of the city and adjoining areas. The city suffers from air pollution caused by road dust and industry with contributions from unclean engines in transportation, especially diesel-powered city buses and trucks, 2-wheelers and 3-wheelers with two-stroke engines. Main contributors to particulate matter in the PM10 range, as a recent study shows, are road dust (50%), industry (23%) and vehicles accounted for only 7%. Among industrial contributors, power plants within Delhi city are the main culprits. In May 2014 the World Health Organization announced New Delhi as the most polluted city in the world. Weather, geography, population growth and energy consumption all play key roles in the ongoing air pollution problem in Delhi. The combination elevates the concentrations of air pollutants, including ultra-fine particles which are the most harmful to human health, and contributes to thousands of deaths per year. There is already evidence of a spectrum of health problems, ranging from allergies and respiratory conditions, malformations, growth restrictions and even an increasing incidence of cancers, all of which could be related to increased pollution. ENVIS team of JNU, New Delhi, tried its best to compile abstracts related to aerosol and air pollution.

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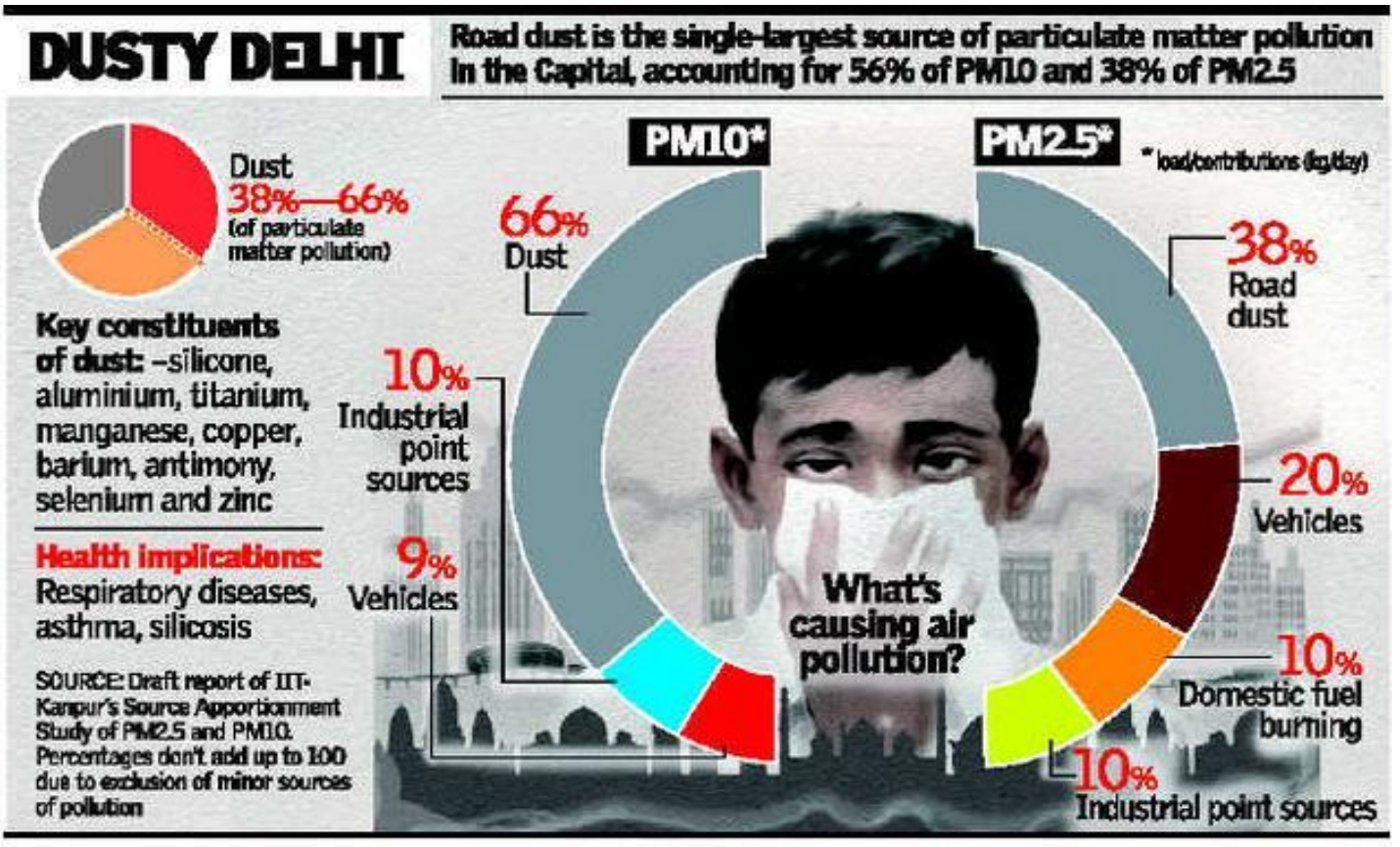

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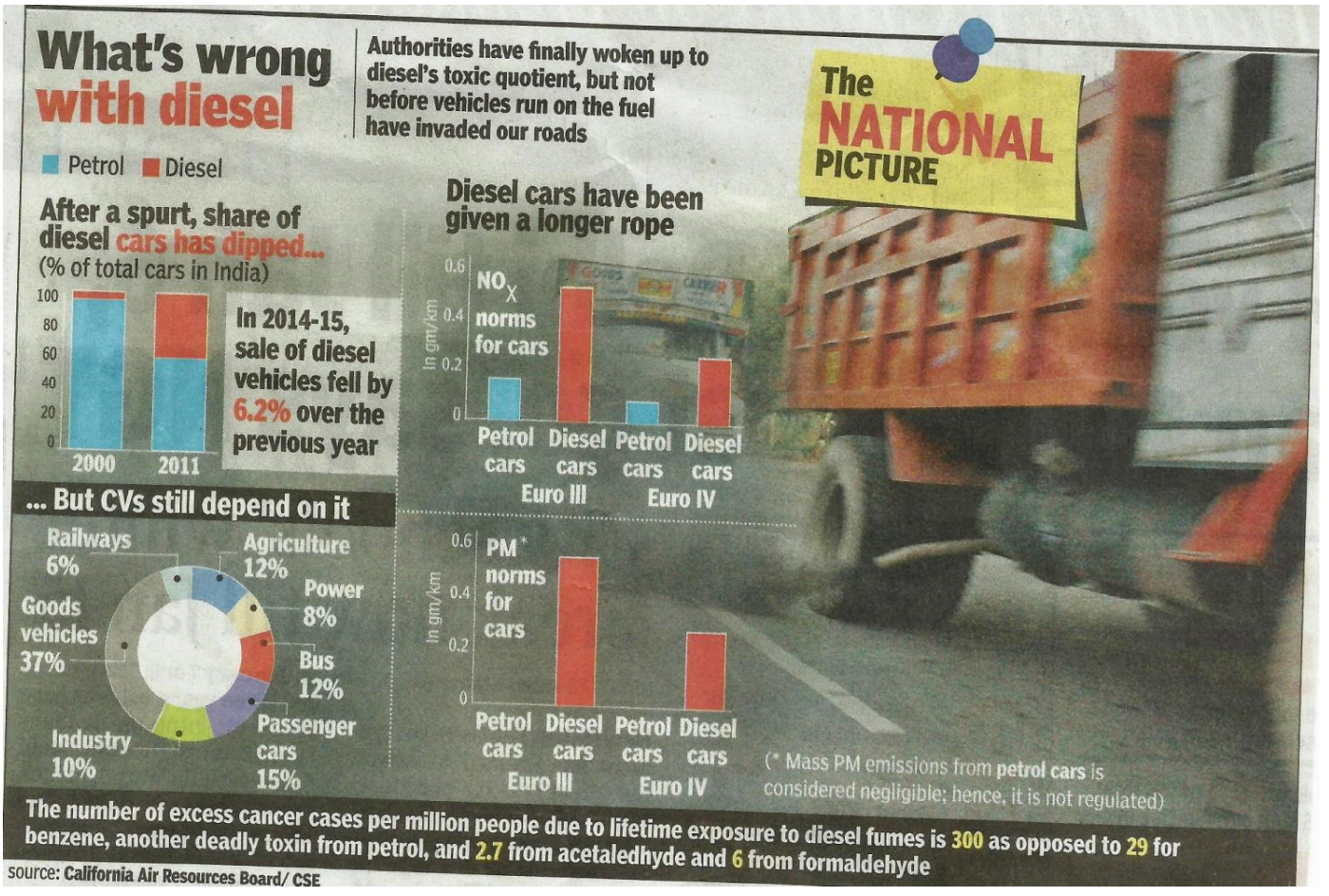
Entitled: Cars are not biggest polluters in Delhi.



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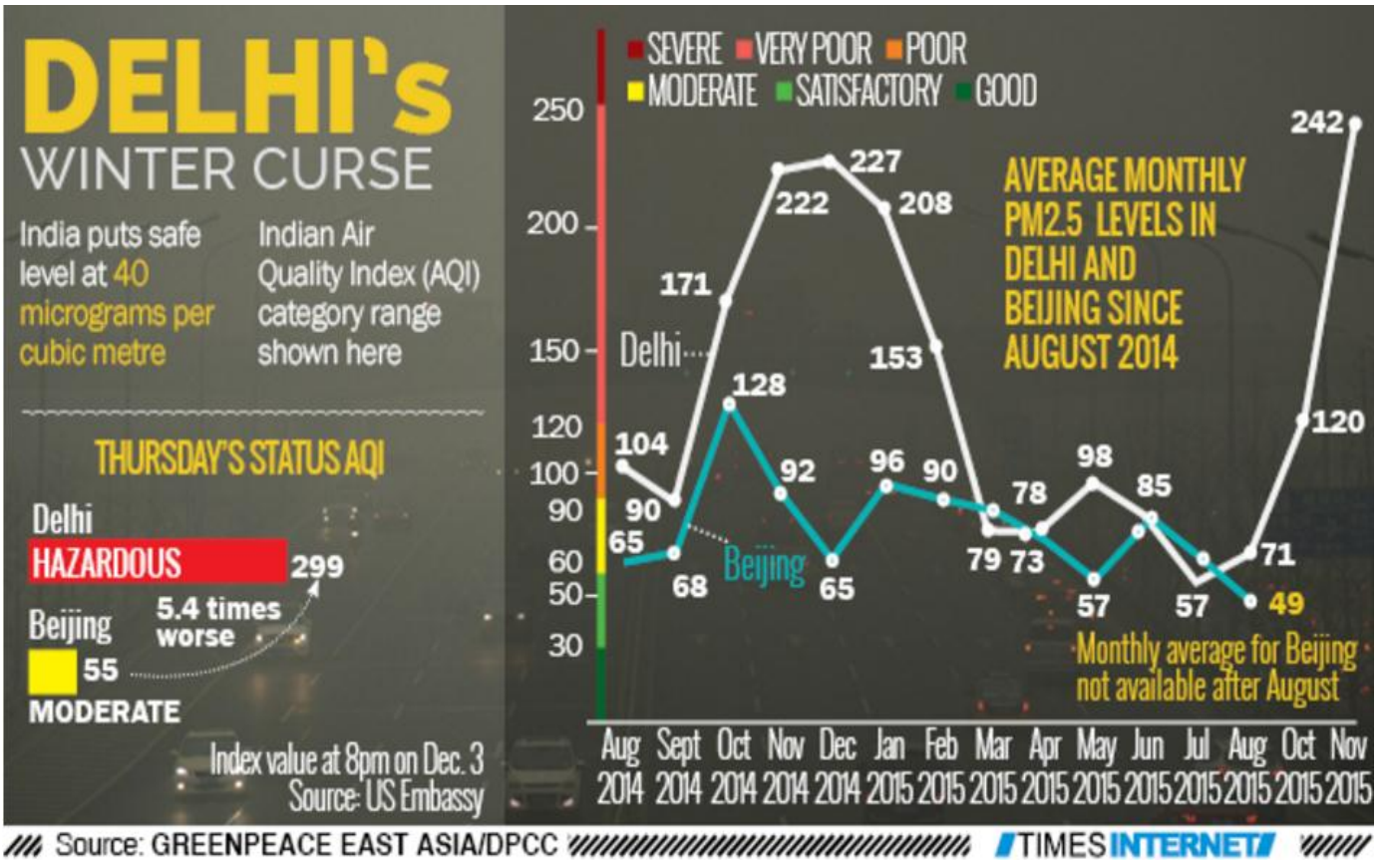
Entitled: NGT not sure Delhi can work out odd-even



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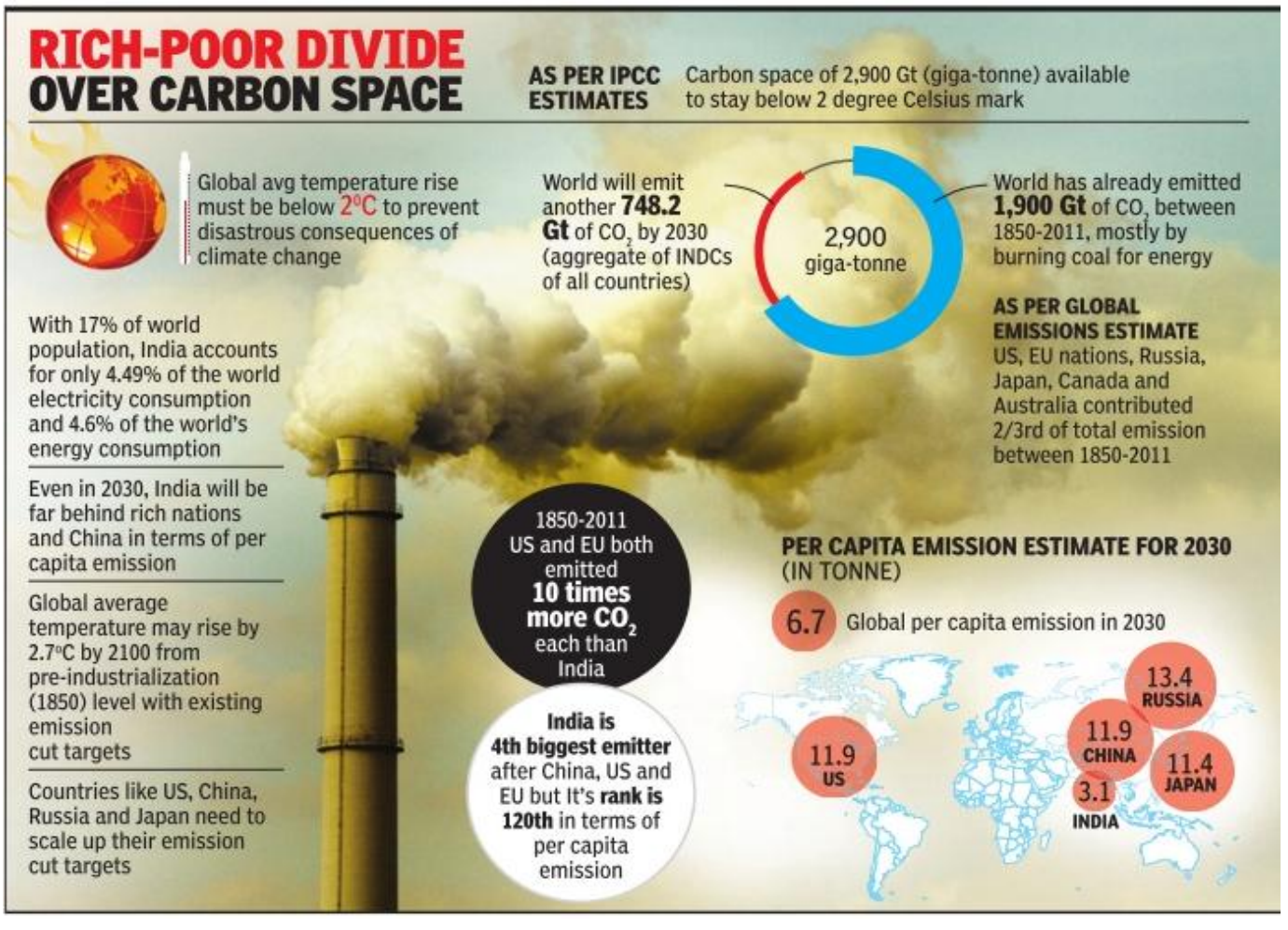
Entitled: Bad air: Delhi races ahead of Beijing



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Entitled: India thwarts coal heat at Paris meet

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City-wide sweeping a source for respirable particulate matter in the atmosphere

Ankit Tandon, Sudesh Yadav, Arun K. Attri

ABSTRACT

Most of the cities located in Northern India are afflicted with the presence of unusually high concentration of PM10 in the ambient environment posing a serious risk to human health. To understand the reasons underlying the persistence of the high levels of PM10 in the Delhi region, a novel experiment was designed by appropriating a well-known tracer source— Diwali fireworks—emitting a large amount of particulate matter (PM) in the atmosphere. Sequential eight hourly PM10 samples were collected and analyzed for the elemental signatures associated with the tracer and other sources. Principal component analysis was used to resolve the sources; their respective mass contribution to PM10 load, in time sequence, was estimated using absolute principal component score method. The results suggest that the well-established practice of city-wide street-cleaning, resuspends the surface deposited PM10 back to the atmosphere. We suspect that this practice resuspends about 25% of the sedimented PM10 back into the atmosphere.

Atmospheric Environment, Volume 42, Issue 5, February 2008, Pages 1064–1069

http://www.sciencedirect.com/science/article/pii/S1352231007011314

Analysis of annual cyclic variations in total ozone column over Indian region

Ankit Tandon & Shweta Yadav & Arun K. Attri

ABSTRACT

Annual Cyclic Variations (ACV) in the Total Ozone Column (TOC) were estimated in latitudinally averaged Multi Sensor Reanalysis (MSR) monthly mean TOC time-series data-set from Jan 1979 to Dec 2008 for Indian region. The TOC contents over any latitude is controlled by the photochemistry and dynamics present in different regions of the stratosphere and troposphere, correlation between ACV in TOC, and ACV in other climatic and dynamical factors—(i) Solar Insolation on a horizontal surface at the top of the atmosphere (ETSI); (ii) ZonalWind at 30 hPa pressure level (ZW); (iii) Meridional Wind at 30 hPa pressure level (MW); and (iv) Air Temperature at 30 hPa pressure level (AT)—were taken into account to understand their role in the annual cyclic variability present in the TOC over Indian region. Contributions of ACVpresent in these climatic and dynamical factors to the ACV in TOC were ascertained by performing a multiple linear regression analysis by taking ACV in ETSI, ACV in ZW and ACV in AT as independent variables (co-variates) for ACV in TOC. It is concluded that in the tropical part of Indian region ACV in TOC is largely controlled by the photochemistry; whereas in the subtropical part of the region, the dynamics present in the stratosphere mainly decides ACV in TOC.

Journal of Atmospheric Chemistry, December 2012, Volume 69, Issue 4, pp 321-335

http://link.springer.com/article/10.1007%2Fs10874-012-9243-4

Characterization of aerosol associated non-polar organic compounds using TD-GC-MS: A four year study from Delhi, India

Shweta Yadav, Ankit Tandon, Arun K. Attri

ABSTRACT

Aerosol associated Non-Polar Organic Compounds (NPOCs) – 25 n-alkanes, 17 Polycyclic Aromatic Hydrocarbons (PAHs), and 3 Isoprenoid hydrocarbons – have been identified and quantified in PM_{10} samples collected over four years in time sequence (2006–2009), using Thermal Desorption Gas Chromatography Mass Spectrometry, in Delhi region. Established organic markers, associated diagnostic parameters, and molecular diagnostic ratios were used to assess and discern the contributing biogenic, petrogenic and pyrogenic sources to NPOCs. Analysis show that anthropogenic contributions to NPOCs exhibit increase from 2006 to 2009. Distribution profiles of NPOCs were significantly affected by change in season. Lower concentrations of NPOCs during summer months, and higher during winter, once scaled to Planetary Boundary Layer height, suggests that contributing sources were most

active during summer months. During monsoon season high mass fractions of Total n-alkanes (ppm), Total PAHs (ppm), and Black carbon (BC) % alludes at the role of differential washout process involving hydrophilic and hydrophobic fractions of ambient aerosols. Significantly high, four year average concentrations of TPAH and BC signify the dominance of pyrogenic source contributions to PM_{10}. High correlation between monthly mean concentrations of TPAH and BC (R_2 = 0.75) suggests that besides common emission source, they are also contributed, individually, by exclusive independent sources.

Journal of Hazardous Materials, Volumes 252–253, 15 May 2013, Pages 29–44

http://www.sciencedirect.com/science/article/pii/S0304389413001337

Coupling between meteorological factors and ambient aerosol load

Ankit Tandon, Sudesh Yadav, Arun K. Attri

ABSTRACT

The coarser (CPM) and respirable (RPM) fractions of aerosol loads collected in a time sequence, during the onset of winter season in Delhi region, were subjected to Principal Component Analysis (15 elemental variables, 39 samples); the absolute mass contributed by each identified source to the CPM and RPM was quantified by using Absolute Principal Component Score (APCS) and Positive Matrix Factorization (PMF) method. Interestingly, the mass contributed by the local crustal source (material) to both fractions manifested undulating periodic behavior, a dominating harmonic corresponding to 24-h period was detected by using Discrete Fourier Transform (DFT). The corresponding harmonics, of varying strengths, were also detected in the recorded meteorological factors: Planetary Boundary Layer (PBL), Surface Level Temperature (T), Surface Level Relative Humidity (RH) and Wind Speed (WS). The analysis of the respective harmonic strength within the CPM, RPM, and meteorological factors suggested that the undulation observed in both size fractions of aerosol load from the local crust was affected by the meteorological factors. The large proportion of undulating loads (CPM and RPM), explained by the dominating harmonic, was fully accounted for by the empirical relation involving the discrete coupling parameters, and the recorded meteorological factors: PBL, T, RH and WS. The analysis suggests that the magnitude and the direction ('positive' load increase and 'negative' the reverse) of coupled meteorological factors'(s) effect on ambient CPM, RPM load is determined by the phase difference between the harmonic explaining the aerosol fraction's load and the corresponding harmonic present in the respective meteorological factor. The absolute mass contributions arising from the identified sources (APCS and PMF) allowed us to calculate the baseline ambient concentrations of undulating CPM and RPM loads, in the region of this study, affected by meteorological factors only.

Atmospheric Environment, Volume 44, Issue 9, March 2010, Pages 1237–1243

http://www.sciencedirect.com/science/article/pii/S1352231010000063

Impact of CNG on emissions of PAHs and PCDDs/Fs from the road transport in Delhi

Ragini Kumari, Arun K. Attri, Bhola R. Gurjar

ABSTRACT

In this paper we present the first estimates and inventory of polycyclic aromatic hydrocarbon (PAH) emissions from mobile sources in megacity Delhi, India for the period 1999.2006. The "COPERT 4" model was used to estimate 23-species of PAHs and 5-congeners of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzo-furans (PCDFs) from the gasoline, diesel, and CNG (compressed natural gas) fuelled vehicles. Our study shows that the total annual emissions of Σ23.PAHs from road transport has increased ~4 times and emissions of Napthalene (Nap) emerged as the most prominent (8 times), whereas a two-fold increase was seen for the carcinogen benzo[a]pyrene (BaP) and benzo[a]pyrene equivalence (BaPeq) emissions between 1999 and 2006 from the road transport alone. Further increase in total PCDDs and PCDFs by ~3 times can made air quality even worse. Estimated emission share of low molecular weight PAHs (2-ring) has increased (from 43%.85%), whereas vice-versa for ones with high molecular weights. Switch-over to CNG especially for public transport resulted into an offset of 21% emissions of Σ23.PAHs, 14% in BaP, and 15% in BaP_{eq} for the year 2006. It is also observed that the PAH emissions from CNG

fuelled vehicles have decreased, but overall increase in the share of private vehicles (1.5 times) has outweighed this benefit.

Atmospheric Pollution Research; July 2011, Vol. 2, Issue 3, Page: 394
http://connection.ebscohost.com/c/articles/64287480/impact-cng-emissions-pahs-pcdds-fs-from-road-transport-delhi

Implications of Variation in Carbon Sources for the Global Warming Potential of Methane

C. K. Varshney, A. K. Attri

ABSTRACT

Methane is the most important biogenic greenhouse gas (GHG) next to carbon dioxide (CO_2) and water vapours. Since industrialization its concentration in atmosphere has grown by 145 per cent over its pre-industrial concentration (Hogan & Harris, 1994; Khalil & Rasmussen, 1994). Paddy fields are one of the major anthropogenic sources of methane emission (Bachelet & Neue, 1993). Methane emission has attributed considerable attention because of its concordance with paddy cultivation in the tropical countries of South and South East Asia. Initial estimates of methane emission from paddy cultivation were made by IPSEP (1989) and IPCC (1990), however, over the years, earlier estimates of the emission have been scaled down substantially (Dixon *et al.*, 1994). Certain crucial demeanors of methane emission in the context of global warming (GW) have bypassed the current debate, including the recent IPCC (1994–95) assessments. The objective of this chapter is to highlight the importance of the nature and the dynamics of methane in relation to carbon source and their implication to global warming potential (GWP) of methane. It also underscores the need to visualize methane emission from rice paddies, natural wetlands and other biogenic sources from ecological and carbon cycling perspective.

Environmental Stress: Indication, Mitigation and Eco-conservation, pp 103-106
http://link.springer.com/chapter/10.1007%2F978-94-015-9532-2_9

Microclimate: Formation of ozone by fireworks

Arun K. Attri, Ujjwal Kumar, V. K. Jain

ABSTRACT

Ozone is a secondary pollutant and greenhouse gas that is formed from molecular oxygen in the presence of sunlight and nitrogen oxides. The extent of production also depends on the presence of volatile hydrocarbons, carbon monoxide and methane. But we have discovered a surprising source of ozone which is generated in spontaneous bursts even in the absence of sunlight and nitrogen oxides— namely, the exuberant mass of colour emitting sparklers that are lit during the Diwali festivities, which take place every year during October and November in Delhi, India. The underlying process of ozone formation resembles that induced by ultraviolet radiation in the stratosphere. We undertook a routine, real-time monitoring of the concentrations of NO*x* (NO and NO_2), O_3 and other microclimatic factors at a known pollutant-receptor site9 in Delhi in order to determine the effects of burning unprecedented numbers of fireworks on the local environment during the festive period in November 1999. We found that during the festival period the ozone concentration peaked at around noon and fell to negligible levels after sunset. On Diwali night (7 November), a small build-up of O_3 (951 parts per billion by volume) was detected between 20:40 and 02:30 hours (results not shown). During this period, no correlation was found between NO*x* concentration and O_3 formation, indicating that the ozone was unlikely to have been generated in reactions involving ambient NO*x*. This observation was surprisingly different from night-time O_3 measurements obtained on the other dates, when no O_3 formation was detected. Further experiments carried out under different climatic conditions showed that there is a linear regression between the total amount of inflammable material present in sparklers and the cumulative O_3 formed (correlation, 0.993). There was no change in ambient NO*x* concentration before, during or after these experiments. Sparklers depend on a combination of different metal salts to generate their colour and sparkle — these include potassium perchlorate, sulphur, strontium nitrate, barium nitrate, sodium oxalate, calomel, aluminium and manganese. When burnt, a significant proportion of the light emitted by these constituents has a wavelength below 240 nm. The radiative energy of

these emissions is sufficient to dissociate atmospheric molecular oxygen into atomic oxygen, enabling the reaction $O_2+O \rightarrow O_3$ to take place. This proposed mechanism could explain the formation of
bursts of O_3 without the participation of NO*x*, and is therefore similar to the process of ultraviolet-radiation-induced formation of O_3 in the stratosphere.

***Nature* 411, 1015 (28 June 2001) | doi: 10.1038/35082634**
http://www.nature.com/nature/journal/v411/n6841/full/4111015a0.html

Monthly and Seasonal Variations in Aerosol Associated *n*-alkane Profiles in Relation to Meteorological Parameters in New Delhi, India

Shweta Yadav, Ankit Tandon, Arun K. Attri

ABSTRACT

A one-year extensive investigation to assess monthly and seasonal variations in the PM10 associated homologous series of *n*-alkane (C11–C35) profiles was carried out in New Delhi, India. Quantitative estimation of *n*-alkanes, involving 3–4 PM10 samples/month, was done by using thermal desorption gas chromatography mass spectrometry (TD-GC-MS). Significant seasonal variations were observed, both in mass concentrations (annual mean: 517 ± 256 ng/m3) and mass fractions (annual mean: 4368 ± 2067 ppm) of total *n*-alkanes (C11–C35). The impact of the Planetary Boundary Layer (PBL) on the *n*-alkane profiles was the most significant among all the meteorological parameters considered. A strong positive correlation (r = 0.84) between PM10 load (µg/m3) and mass concentrations of total *n*-alkanes (ng/m3) was observed; whereas a negative correlation (r = –0.72) was seen between the PM10 load and mass fractions of total *n*-alkanes (ppm). Annual mean values of the Carbon Preference Index (CPI) and Wax *n*-alkanes percentage (WNA%) stood at 2.2 ± 0.6 and 39 ± 10%, respectively. Established diagnostic tools indicated that during autumn, the dominant inputs of aerosol associated *n*-alkanes came from petrogenic (vehicular and industrial) emissions (72 ± 7%), with lesser contributions from biogenic activities (28 ± 7%). In other seasons, although petrogenic sources remained a dominant contributor (53 ± 6%–59 ± 14%), the contributions from biological sources were also comparable (41 ± 14%–47 ± 6%). Emissions of total *n*-alkanes from both petrogenic and biogenic sources were maximum during spring. In the rest of the months, small variations were observed in the emissions of total *n*-alkanes from petrogenic sources, whereas large variations were noted in the emissions from biogenic sources.

Aerosol and Air Quality Research, 13: 287–300, 2013
http://aaqr.org/VOL13_No1_February2013/28_AAQR-12-01-OA-0004_287-300.pdf

Morphological characterization of carbonaceous aggregates in soot and free fall aerosol samples

Kamna Sachdeva, Arun K. Attri

ABSTRACT

The morphological characteristics of BC aggregates present in the soot and carbonaceous aerosol (CA) samples were investigated. The process of soot formation under laboratory conditions took into account the commonly used practice of burning fuel in the households in India. The fractal morphology was determined by using box counting algorithm and maximum projected area of the aggregates by using their digital electron microscopic images. Former provided the estimates of perimeter fractal dimension (PDf) of each aggregate, and later estimated the average density fractal dimension (DDf) of aggregate groups. Numbers of particles constituting the aggregates, using projected area approach, were significantly higher than the estimates based on pixel counting. The measured average diameter of the primary particles in aggregates, ranged between 24 and 57 nm. The fractal dimensions, PDf, for the laboratory-generated soot aggregates varied from 1.36 to 1.88. The PDf for aggregates derived from diesel-vehicles and biomass burning showed significant variation: biomass, 1.27; diesel vehicle, 1.82 and 1.7. The size and the dimensions estimated for the free fall CA samples showed large deviation. The ratio L/Rg (length/radius of gyration) for soot aggregates (gasoline, kerosene, diesel, mustard oil and hexane) ranged from 3.5 to 4.8. Surface morphology of these aggregates, using scanning electron microscope (SEM), showed the presence of spherical ‘‘charred cenosphere’’ like particles in gasoline and free fall aerosol aggregates. FTIR

investigations revealed the presence of a large number of organic groups (OC) associated with carbonaceous aggregates present in soot and free fall aerosol samples.

Atmospheric Environment, Volume 42, Issue 5, February 2008, Pages 1025–1034

http://www.sciencedirect.com/science/article/pii/S1352231007008862

Non–linear analysis of short term variations in ambient visibility

Ankit Tandon, Shweta Yadav, Arun K. Attri

ABSTRACT

Ambient visibility is a complex manifestation arising out of interactions among many atmospheric variables, including ambient aerosol load, and region specific geophysical characteristics. To functionally relate visibility impairment in Delhi region during winter months–months marred with poor visibility condi□ons–a novel experiment was designed to relate visibility with ambient aerosol load (PM2.5), and relevant meteorological variables: dew point temperature (Dp), height of planetary boundary layer (PBL), ambient temperature (T), relative humidity (RH), wind speed (WS) and wind direction (WD). Time series data sets of Visibility(t) and other variables were subjected to non–linear decomposition using Empirical Mode Decomposition Method (EMD), enabling to obtain total cyclic and acyclic–trend components embedded in all data–sets. Extracted total cyclic visibility components were functionally related with the corresponding components associated with PM2.5 load and meteorological variables. Decomposed acyclic–trend component of the visibility, representing time dependent acyclic trend (AT), was separately related with the corresponding AT components of the considered meteorological variables. The decomposed components of the visibility (total cyclic and AT) were subjected to multiple linear regression to establish a functional relationship between them and a set of variables among the considered variables. The analysis suggests that acyclic–trend associated with Visibility(t) can be predicted better as opposed to the Visibility(t)cyclic component.

Atmospheric Pollution Research (APR), Volume: 4 Issue: 2 Pages: 199-207, Year: April 2013

http://www.atmospolres.com/articles/Volume4/issue2/abstract8.htm

Statistical assessment of respirable and coarser size ambient aerosol sources and their timeline trend profile determination: A four year study from Delhi

Shweta Yadav, Ankit Tandon, Jayant K. Tripathi, Sudesh Yadav, Arun K. Attri

ABSTRACT

A reliable identification of sources and their relative time dependent contributions to ambient aerosol load is an important air pollution research problem. Given the inherent complexity of contributing sources in urban/mega-cities, an appropriate statistical investigation is needed to characterize sources and to understand their timeline trend profiles. Daily average ambient particulate matter (PM) loads, PM10 (aerodynamic diameter <10 mm) and coarser particulate matter (CPM: aerodynamic diameter >10 mm) were collected once a week over 4 years at a receptor site in Delhi. The samples were analyzed to quantify the presence of 17 marker elements. Time series data of PM loads, and that of associated marker elements was subjected to Positive Matrix Factorization (PMF) to identify sources and to quantify their contributions to each PM fraction with reference to the associated marker elements. The resolved time series data of each contributing source was further subjected to Ensemble Empirical Mode Decomposition (EEMD) analysis to extract their timeline trend profile over four years in CPM and PM10 load. Three sources contributed to the CPM load: anthropogenic (15%), primary crustal (59%), and fine crustal dust (26%). Four sources contributed to the PM10 load: coarser grain crustal material (9%), fine grain crustal material (12%), industrial and vehicular emissions (23%), and wind assisted transport and re-suspension of surface dust (56%). The timeline trend of sources contributions to CPM and PM10 displayed a non-linearity. The unique composite-PM10 source contributed maximum to the ambient PM10 load. Distinct underlying processes of this source involved convective re-suspension and city-wide cleaning associated upliftment of surface deposits back into the ambient environment.

Atmospheric Pollution Research, (2015) 1-11

http://www.sciencedirect.com/science/article/pii/S1309104215000495

Timeline trend profile and seasonal variations in nicotine present in ambient PM10 samples: A four year investigation from Delhi region, India

Shweta Yadav, Ankit Tandon, Arun K. Attri

ABSTRACT

The detection of nicotine, an organic tracer for Environmental Tobacco Smoke (ETS), in the collected PM10 samples from Delhi region's ambient environment, in a appropriately designed investigation was initiated over four years (2006e2009) to: (1) Comprehend seasonal and inter-annual variations in the nicotine present in PM10; (2) Extract regression based linear trend profile manifested by nicotine in PM10; (3) Determine the non-linear trend timeline from the nicotine data, and compare it with the obtained linear trend; (4) Suggest the possible use of the designed experiment and analysis to have a qualitative appraisal of Tobacco Smoking activity in the sampling region. The PM10 samples were collected in a monthly time-series sequence at a known receptor site. Quantitative estimates of nicotine (ng m_3) were made by using a Thermal Desorption Gas Chromatography Mass Spectrometry (TD-GC/MS). The annual average concentrations of nicotine (ng m_3) were 516 ± 302 (2008) > 494 ± 301 (2009) > 438 ± 250 (2007) > 325 ± 149 (2006). The estimated linear trend of 5.4 ng m_3 month_1 corresponded to 16.3% per annum increase in the PM10 associated nicotine. The industrial production of India's tobacco index normalized to Delhi region's consumption, pegged an increase at 10.5% per annum over this period.

Atmospheric Environment, Volume 98, December 2014, Pages 89–97

http://www.sciencedirect.com/science/article/pii/S1352231014006608

Trends in total ozone column over India: 1979-2008

Ankit Tandon, Arun K. Attri

ABSTRACT

Time-series decomposition analysis was performed on, (1) Multi Sensor Reanalysis (MSR) Total Ozone Column (TOC) monthly mean time-series data-set [1979-2008], and (2) Total Ozone Mapping Spectrometer (TOMS) Version 8 Overpass monthly mean time-series data-set from Nimbus 7 satellite, (TOMS N7) [1979-1993] to estimate long-term linear trends in the data to assess a scale of surface UV changes over India. Long-term trend estimation, subsequent to the removal of annual cyclic variations, for MSR TOC data-set was done over Indian region covering latitude spread 0˚N - 40˚N, and Longitude spread 67.5˚E to 97.5˚E. Trend estimates for TOMS Overpass data-sets, treated on similar lines, was done for fifteen locations over India (1˚19'N to 34˚04'N). Statistically significant declining trends ranging from (-) 0.8 - (-) 1.5 percent/decade were seen over Indian region above 25˚N latitude in MSR TOC data-set (1979-2008). In case of TOMS N7 data-set (1979-1993), statistically significant declining trends were estimated over New Delhi (28˚40'N) and Srinagar (34˚04'N) with a value of (-) 2.5 and (-) 3.6 percent/ decade respectively. Observed TOC decline covered 40% of total geographical area of Indian region, however rest of the Indian region (peninsular) did not show statistically any significant trend.

Atmospheric Environment, Volume 45, Issue 9, March 2011, Pages 1648–1654

http://www.sciencedirect.com/science/article/pii/S135223101100015X

Biomass Combustion a Dominant Source of Carbonaceous Aerosols in the Ambient Environment of Western Himalayas

Ajay Kumar, Arun K. Attri

ABSTRACT

Use of biomass combustion as primary energy source emit substantial amounts of carbonaceous aerosols (CA) in the Himalayan environment. Any understanding regarding the impact of CA on human health and climate requires a reliable estimation of compositional variability of CA associated carbon forms: Elemental carbon (EC), Organic carbon (OC), and Light absorbing organic carbon (LAOC). This investigation spanning over 14 months was undertaken in the rural part of the Western Himalayas to estimate temporal variability in the ambient aerosol load (PM10, PM2.5), CA associated carbon forms. All CA associated carbon forms were part of PM2.5 size fraction, their significantly high concentrations in winter corresponded with the high biomass combustion. Source apportionment

of CA done on the basis of Char-EC/Soot-EC estimates showed that >90% of the EC was Char-EC contributed by biomass and coal combustion in winter. Estimates of K+ (tracer for biomass combustion) showed a strong association with CA associated carbon forms. The estimated values of CA associated carbon forms during winter matched with the reported values of emission factors for biomass burning. Both the mass and composition of ambient aerosol were predominantly contributed by biomass combustion in the region.

Aerosol and Air Quality Research, Accepted Manuscript, DOI: 10.4209/aaqr.2015.05.0284, 30 October, 2015
http://www.aaqr.org/Doi_J.php?id=AAQR-15-05-SIMtS-0284_accepted

Profile of particulate-bound organic compounds in ambient environment of Srinagar: a high altitude urban location in the North Western Himalayas

Behjat Huma, Shweta Yadav, Arun K. Attri

ABSTRACT

Twenty-four hourly samples of total suspended particulate matter (TSPM) were collected once a week over 17 months in the ambient environment of Srinagar (altitude 1524 m), an urban montane location in the North-Western Himalayas. The samples were analyzed to identify and quantify the presence of diverse organic compounds (OCs) using thermal desorption gas chromatography mass spectroscopy (TD-GCMS). Non-polar organic compounds –n-alkanes, polycyclic aromatic hydrocarbons (PAHs), and molecular tracers (retene and nicotine), were detected in the TSPM samples. Molecular diagnostic ratios, derived from the quantified n-alkanes and PAHs in TSPM, assisted in characterization of the contributing sources. Significant variation in the planetary boundary layer height (meters) with change in season (summer to winter) in this region, also, affected the observed variations in the temporal profile of TSPM-bound OCs. TSPM-bound OCs were predominantly contributed from petroleum and biomass combustion; to a lesser extent from biogenic sources. High concentrations of retene and nicotine, known molecular tracers for coniferous wood combustion and tobacco smoke, respectively, were detected in the winter samples. Seasonal variation in TSPM-bound retene corresponded with the periodicity of biomass burning activity in the region. The benzo(a)pyrene equivalent (BAPE) concentrations, a measure for the carcinogenicity of TSPM-bound PAHs was calculated and the value exceeded the prescribed international standards in winter. This finding poses a major health concern for the inhabitants of this region. High BAPE concentration of PAHs during winter was linked to fossil fuel and biomass combustion, where the prevalent meteorology and topography played a synergistic role.

ICPEP-4 (Fourth International Conference on Plant & Environmental Pollution) 8-11 December 2010, Climate Change, SI/O-8, Page No.-6
http://www.scribd.com/doc/47228811/Icpep-4-Abstract#scribd

Prof. V.K. Jain :

http://www.jnu.ac.in/FacultyStaff/ShowProfile.asp?SendUserName=vkjain

A Comparative Study of Air Quality Index Based on Factor Analysis and US-EPA Methods for an Urban Environment

Biswanath Bishoi, Amit Prakash, V.K. Jain

ABSTRACT

There are many different air quality indexes, which represent the global urban air pollution situation. Although the index proposed by USEPA gives an overall assessment of air quality, it does not include the combined effects (or synergistic effects) of the major air pollutants (Shenfeld, 1970; Ott and Thom, 1976; Thom and Ott, 1976; Murena, 2004). So an attempt is made to calculate the Air Quality Index based on Factor Analysis (NAQI) which incorporates the deficiencies of USEPA method. The daily, monthly and seasonal air quality indexes were calculated by using both these methods. It is observed that a significant difference exists between NAQI and EPAQI. However, NAQI followed the trends of EPAQI when plotted against time. Further, the indexes were used to rank various seasons in terms of air pollution. The higher index value indicates more pollution in relative terms. Moreover, the index may be used for comparing the daily and seasonal pollution levels in different sites.

Volume 9, No. 1, March 2009, Pages 1-17**Aerosol and Air Quality Research**

http://www.aaqr.org/Doi.php?id=1_AAQR-08-02-OA-0007&v=9&i=1&m=3&y=2009

Characterization and source identification of polycyclic aromatic hydrocarbons (PAHs) in the urban environment of Delhi

Homdutt Sharma, V.K. Jain b, Zahid H. Khan

ABSTRACT

This paper reports on polycyclic aromatic hydrocarbons (PAHs) in the atmospheric particulate matter of Jawaharlal Nehru University campus, an urbanized site of New Delhi, India. Suspended particulate matter samples of 24 h duration were collected on glass-fiber filter paper for four representative days in each month during January 2002 to December 2003. PAHs were extracted from filter papers using toluene with ultrasonication method and analysed. Quantitative measurements of polycyclic aromatic hydrocarbons (PAHs) were carried out using the gas chromatography technique. The annual average concentration of total PAHs were found to be 668 ± 399 and 672 ± 388 ng/m3 in the years 2002 and 2003, respectively. The seasonal average concentrations were found to be maximum in winter and minimum during in the monsoon. The results of principal component analysis (PCA) indicate that diesel and gasoline driven vehicles are the principal sources of PAHs in all the seasons. In winter coal and wood combustion also significantly contribute to the PAH levels.

Chemosphere, Volume 66, Issue 2, January 2007, Pages 302–310

http://www.sciencedirect.com/science/article/pii/S0045653506005832

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A study to characterize the suspended particulate matter in an indoor environment in Delhi, India

Arun Srivastava, V.K. Jain

ABSTRACT

To investigate potential particulate matter (PM) exposure, and the possible effective measures for interventions and assessment of sources in indoor environments, a pilot study was conducted at Jawaharlal Nehru University (JNU), New Delhi. The indoor particles were collected from 5th April to 26th June 2000, using a tapered element oscillating microbalance (TEOM). The particles were analyzed by gravimetry, atomic absorption spectrometry (AAS) and scanning electron microscopy (SEM) in order to investigate the mass concentration, physico-chemical properties and morphology of the particles. The gravimetric and AAS results confirmed that the suspended particulate matter (SPM) and metal concentrations were higher than the National Ambient Air Quality Standards (NAAQS) for Delhi. The maximum contributions of SPM were observed to be due to wind-blown crustal dust and vehicular pollution. The SEM analysis of particles showed the presence of a variety of particles, but confirmed the dominance of silicon and soot particles.

Building and Environment, Volume 42, Issue 5, May 2007, Pages 2046–2052

http://www.sciencedirect.com/science/article/pii/S0360132306000722

Comparative Study of Bioaerosol During Monsoon And Post- Monsoon Seasons At Four Sensitive Sites In Delhi Region

Himanshu Lal, Teenu Punia, Bipasha Ghosh, Arun Srivastava and V. K. Jain

ABSTRACT

A comparative analysis of culturable air borne microorganisms in post-monsoon and monsoon season was done by measuring their ambient levels at four different sites within Delhi premises which included both indoor and outdoor. Higher fungal concentration (between the range 36 – 97.33 CFU × 102 m-3) was found in post – monsoon season with Library canteen showing the maximum of 97.33 CFU × 102 m-3. A pattern of minimum concentration of fungal bioaerosol ranging between 2 – 6.6 CFU × 102 m-3 was seen in the monsoon period where Garbage site had the least concentration of 2 CFU × 102 m-3. Similar to fungal concentration, both gram positive and gram negative bacteria revealed maximum concentration in post monsoon season in comparison to monsoon season. Among all four sites maximum gram positive bacterial concentration of 93.33CFU × 102 m-3 was found in library canteen in post- monsoon period while minimum concentration of 4.66 CFU × 102 m-3 in garbage site in monsoon period. The comparative analysis reveals higher concentration of viable air borne microbes in post- monsoon season than in the monsoon period at the indoor sites in comparison to the outdoor ones which may have resulted due to seasonal rain wash. Most of the fungal bioaerosol identified is associated with allergic and immunotoxic diseases such as sick building syndrome. Since the sampling occurred in two different seasons in outdoor and indoor sites with naturally ventilated buildings, external temperature and humidity did vary significantly during the study. Thus, it is more likely that the types of organisms and concentration level observed were related to both the sources (decomposing garbage, spores carried from wooden areas, etc.) as well as the ambient or indoor environmental conditions.

International Journal of Advancement in Earth and Environmental Sciences, Vol. 1, No. 2 (2013)

http://www.irosss.org/ojs/index.php/IJAEES/article/view/84

Estimation of bioaerosol in indoor environment in the university library of Delhi

Bipasha Ghosh, Himanshu Lal, Rajesh Kushwaha, Naba Hazarika, Arun Srivastava and Vinod Kumar Jain

ABSTRACT

Ambient levels of viable bioaerosol (fungi, Gram positive and negative bacteria) were measured in Central Library, Jawaharlal Nehru University, New Delhi during July 2011 to October 2012. Study was done at five indoor sites [basement, reading hall, 3rd, 4th and 5th floors] and one outdoor. Air samples were drawn into standard petri dishes using Buck Bio-culture pump at a flow rate of 40 L min-1 for 1 min. This study reveals interesting relationship between the concentration of fungal spores and bacteria in relation to both environmental and human factor. Most observed fungal species detected in the samples were *Rhizopus oryzae, Aspergillus nidulans* and *Aspergillus flavus.* Specific bacterial identification was not possible but Gram staining followed by microscopic analysis helped in deriving the different shapes of bacteria collected. *Bacillus* and *Coccus* were found maximally. Indoor/Outdoor ratio above 1 for fungal spores signified higher source in the indoor environment at different sections. In indoor environment highest fungal concentration was found in Basement (3140 colony-forming units (CFU) m-3) while lowest in 3rd floor (2560 CFU m-3). In case of bacterial concentration both Gram negative and positive bacteria were found maximum in the Reading Hall (792 and 696 CFU m-3, respectively) while lowest in 3rd floor (475 and 437 CFU m-3, respectively). Higher bacterial counts were primarily attributed to the number of library occupants. High concentration may be due to larger rate of shedding of human skin cells, microbes released from respiratory tract and transport of microbes from floor surfaces on suspended particles.

Sustainable Environment Research, 23(3), 199-207 (2013)
http://ser.cienve.org.tw/index.php/list-of-issues/vol-23/216-23-3-2013/990-23-3-5

Identification and characterization of size-segregated bioaerosols at Jawaharlal Nehru University, New Delhi

Arun Srivastava, Manish Singh, V. K. Jain

ABSTRACT

Ambient levels of viable bioaerosol were measured at four different sites on the campus of Jawaharlal Nehru University (JNU), New Delhi, India. Most of the viable bioaerosol was associated with the fungal fraction with the remainder due to bacteria. The highest concentrations of fungi were found at a health center (1,293 cfu/m3). The highest concentrations of both gram-positive (338.8 cfu/m2) and gram-negative (614 cfu/m2) bacteria were found at a garbage dump site. Gram-negative bacteria were found in larger numbers than gram-positive, possibly due to the higher ambient temperatures during their sampling. Most of the fungal bioaerosol identified is associated with immunotoxic diseases such as sick building syndrome and allergic diseases and was found in respirable fractions. Since the bacterial fractions were identified on the basis of morphology, i.e. only to the level of genus, their relationship to health effects could not be established. Although most of the sampling occurred indoors in naturally ventilated buildings, external temperature and humidity did not vary significantly during the study. Thus, it is more likely that the types of organisms and levels observed had more to do with the sources (decomposing garbage, spores carried from wooded areas, etc.) than the ambient or indoor environmental conditions.

Natural Hazards, January 2012, Volume 60, Issue 2, pp 485-499
http://link.springer.com/article/10.1007%2Fs11069-011-0022-3

Particle size distribution of aerosols and associated heavy metals in kitchen environments

Sandeep Gupta & Arun Srivastava & V. K. Jain

ABSTRACT

Mass size distributions of total suspended particulate matter (TSPM) was measured from Sep 2002 to April 2003 in indoor kitchen environments of five locations in Jawaharlal Nehru University (JNU), New Delhi, with the help of a high volume cascade impactor. Particulate matters were separated in five different size ranges, i.e. >10.9 µm, 10.9–5.4 µm, 5.4–1.6 µm, 1.6–0.7 µm and <0.7 µm. The particle size distribution at various sites appears to follow unimodal trend corresponding to fine particles i.e. size range <0.7 µm. The contributions of fine particles are

estimated to be approximately 50% of TSPM and PM10.9, while PM10.9 comprises 80% of TSPM. Good correlations were observed between various size fractions. Regression results reveal that TSPM can adequately act as a surrogate for PM10.9 and fine particles, while PM10.9 can also act as surrogate for fine particles. The concentrations of heavy metals are found to be dominantly associated with fine particles. However, the concentration of some metals and their size distribution, to some extent is also site specific (fuel type used).

Environmental Monitoring and Assessment, July 2008, Volume 142, Issue 1, pp 141-148
http://link.springer.com/article/10.1007%2Fs10661-007-9915-8

Relationships between Indoor and Outdoor Air Quality in Delhi

Arun Srivastava, V. K. Jain

ABSTRACT

The relationship between indoor and outdoor airborne particles was investigated for 24 residential, sensitive, commercial and heavy traffic sites in Delhi, India. Sampling of suspended particulate matter (SPM) was first conducted simultaneously indoors and outdoors at the reference site during February to March 2000, and later at all the sites during February to July 2001. In order to evaluate the heavy metal composition of the SPM, analyses of Mg, Ca, Cu, Cd, Pb, Cr, Mn, Fe and Ni were done by atomic absorption spectrometry (AAS). It was found that the outdoor SPM concentrations do indeed affect the indoor SPM concentrations in varying degrees depending upon the nature of the site. In case of metals Cu, Cr, Cd and Ni, very good correlation between the indoor and outdoor concentrations was observed irrespective of the nature of the site. The correlation between indoor and outdoor for Mg, Fe, Mn and Pb depends upon the nature of the site. No correlation was observed between indoor and outdoor Ca at any of the chosen sites.

Indoor and Built Environment, June 2003, vol. 12, no. 3, 159-165
http://ibe.sagepub.com/content/12/3/159.abstract

Seasonal trends in coarse and fine particle sources in Delhi by the chemical mass balance receptor model

Arun Srivastava, V.K. Jain

ABSTRACT

A study of the source contribution of atmospheric particulate matter and associated heavy metal concentrations using chemical mass balance model Version 8 (CMB8) in coarse and fine size mode has been carried out for the city of Delhi. Urban particles were collected using a five-stage impactor at six sites in three different seasons, viz. winter, summer and monsoon in the year 2001. Five samples from each site in each season were collected. The results obtained indicate the dominance of vehicular pollutants in fine size mode, whilst the contribution in coarse mode to some extent is site specific but largely due to vehicular pollution and, soil and crustal dust. Seasons also play an important role but in coarse size fraction only.

Journal of Hazardous Materials, Volume 144, Issues 1–2, 1 June 2007, Pages 283–291
http://www.sciencedirect.com/science/article/pii/S0304389406012167

SEM-EDX analysis of various sizes aerosols in Delhi India

Arun Srivastava & V. K. Jain & Anchal Srivastava

ABSTRACT

Scanning electron microscopy-energy dispersive X-ray analysis (SEM-EDX) was used to understand the differences in morphology, elemental composition and particle density of aerosols in different five size ranges to further investigate the potential sources as well as transport of pollutants from/at a much polluted and a very clean area of Delhi. Aerosol samples were obtained in five different size ranges viz. ≥10.9, 10.9–5.4, 5.4–1.6, 1.6–0.7 and ≤0.7 µm from a considerably very clean and a much polluted area of Delhi. It was observed that at polluted area most of the particles irrespective of size are of anthropogenic origin. At clean area, in coarse size fractions particles are of natural origin while in fine size range the presence of anthropogenic particles suggests the transport of particles from one area to the other.

Environmental Monitoring and Assessment, March 2009, Volume 150, Issue 1, pp 405-416
http://link.springer.com/article/10.1007%2Fs10661-008-0239-0#page-1

Size distribution and source apportionment of polycyclic aromatic hydrocarbons (PAHs) in aerosol particle samples from the atmospheric environment of Delhi, India

Sandeep Gupta, Krishan Kumar, Arun Srivastava, Alok Srivastava, V.K. Jain

ABSTRACT

Ambient aerosol particles were collected using a five-stage impactor at six different sites in Delhi. The impactor segregates the TSPM into five different sizes (viz. N10.9, 10.9–5.4, 5.4–1.6, 1.6–0.7, and b0.7 μm). Samples collected were chemically analyzed for all the five size ranges, for the estimation of 16 different PAHs. The particle size distribution of PAHs was observed to be unimodal in nature with the highest peak towards the smallest size aerosol particle (b0.7 μm). The five size ranges were categorized into two broad categories viz. coarse (N10.9+10.9 to 5.4+5.4 to 1.6 μm) and fine (1.6 to 0.7+b0.7 μm). It was observed that the dominant PAHs found were pyrene, benzo(a)pyrene, benzo(ghi)perylene and benzo(b)fluoranthene for both the coarse and fine fractions. Source apportionment of polycyclic aromatic hydrocarbons (PAHs) has been carried out using principal component analysis method (PCA) in both coarse and fine size modes. The major sources identified in this study, responsible for the elevated concentration of PAHs in Delhi, are vehicular emission and coal combustion. Some contribution from biomass burning was also observed.

Science of The Total Environment, Volume 409, Issue 22, 15 October 2011, Pages 4674–4680
http://www.sciencedirect.com/science/article/pii/S004896971100831X

Size distribution and source identification of total suspended particulate matter and associated heavy metals in the urban atmosphere of Delhi

Arun Srivastava, V.K. Jain

ABSTRACT

A study of the atmospheric particulate size distribution of total suspended particulate matter (TSPM) and associated heavy metal concentrations has been carried out for the city of Delhi. Urban particles were collected using a five-stage impactor at six sites in three different seasons, viz. winter, summer and monsoon in the year 2001. Five samples from each site in each season were collected. Each sample (filter paper) was extracted with a mixture of nitric acid, hydrochloric acid and hydrofluoric acid. The acid solutions of the samples were analysed in five-particle fractions by atomic absorption spectrometry (AAS). The impactor stage fractionation of particles shows that a major portion of TSPM concentration is in the form of PM0.7 (i.e. <0.7 lm). Similarly, the most of the metal mass viz. Mn, Cr, Cd, Pb, Ni, and Fe are also concentrated in the PM0.7 mode. The only exceptions are size distributions pertaining to Cu and Ca. Though, Cu is more in PM0.7 mode, its presence in size intervals 5.4–1.6 lm and 1.6–0.7 lm is also significant, whilst in case of Ca there is no definite pattern in its distribution with size of particles. The average PM10.9 (i.e. <10.9 lm) concentrations are approximately 90.2% ± 4.5%, 81.4% ± 1.4% and 86.4% ± 9.6% of TSPM for winter, summer and monsoon seasons, respectively. Source apportionment reveals that there are two sources of TSPM and PM10.9, while three and four sources were observed for PM1.6 (i.e. <1.6 lm) and PM0.7, respectively. Results of regression analyses show definite correlations between PM10.9 and other fine size fractions, suggesting PM10.9 may adequately act as a surrogate for both PM1.6 and PM0.7, while PM1.6 may adequately act as a surrogate for PM0.7.

Chemosphere, Volume 68, Issue 3, June 2007, Pages 579–589
http://www.sciencedirect.com/science/article/pii/S0045653506017851

Source apportionment of suspended particulate matters in a clean area of Delhi: A note

Arun Srivastava, V.K. Jain

ABSTRACT

Source apportionment of suspended particulate matters was carried out at Jawaharlal Nehru University, an extremely clean location of Delhi, using chemical mass balance receptor model. The results reveal that diesel vehicles are the major contributors followed by the industrial source. Paved road dust, gasoline vehicles and solid waste contribute 10.2%, 6.2% and 5.8%, respectively. The contribution of soil and crustal dust was minimal. The contributions of most of the sources are generally variable, except the contribution of diesel vehicles.

Transportation Research Part D: Transport and Environment, Volume 13, Issue 1, January 2008, Pages 59–63

http://www.sciencedirect.com/science/article/pii/S1361920907001022

Source Apportionment of Total Suspended Particulate Matter in Coarse and Fine Size Ranges Over Delhi

Arun Srivastava, Sandeep Gupta, V. K. Jain

ABSTRACT

Source apportionment of total suspended particulate matter (TSPM) and associated heavy metals has been carried out for the city of Delhi using the Chemical Mass Balance Model, Version 8 (CMB8), as well as principle component analysis (PCA) of SPSS (Varimax Rotated Factor Matrix method) in coarse- and fine-size mode. Urban particles were collected using a five-stage impactor at six sites in the winter of 2005-06. The impactor segregates the TSPM into five different size ranges (viz. > 10.9, 10.9– 5.4, 5.4–1.6, 1.6–0.7 and < 0.7 µm). Four samples were collected from six different sites every 24 hours. Samples were analyzed in five size ranges gravimetrically and chemically for the estimation of SPM and metals. The five different size ranges were divided into two broad categories: coarse (1.6 to > 10.9 µm) and fine (< 1.6 µm). The CMB8 and PCA were executed separately for both coarse and fine size ranges. Results obtained by CMB8 indicate the dominance of vehicular pollutants (62%), followed by crustal dust (35%) in the fine size range; while in the coarse size range crustal dust dominated (64%) over vehicular pollution (29%). Little contribution from paved-road dust and industrial sources was observed. Results of PCA (or factor analysis) reveal two major sources (vehicular and crustal resuspension) in both coarse and fine size ranges. The correlations of factors (sources) with the metals show that in the coarse size range the dominant source is crustal re-suspension (68%) followed by vehicular pollution (23%). However, this is reversed in the case of the fine size range factor analysis where vehicular pollution (86%) dominated over crustal re-suspension (10%).

Aerosol and Air Quality Research, Vol. 8, No. 2, June 2008, Pages 188-200

http://www.aaqr.org/Doi.php?id=6_AAQR-07-09-OA-0040

Winter-time size distribution and source apportionment of total suspended particulate matter and associated metals in Delhi

Arun Srivastava, Sandeep Gupta, V.K. Jain

ABSTRACT

A study of the winter time size distribution and source apportionment of total suspended particulate matter (TSPM) and associated heavy metal concentrations have been carried out for the city of Delhi. This study is important from the point of view of implementation of compressed natural gas (CNG) as alternate of diesel fuel in the public transport system in 2001 to reduce the pollution level. TSPM were collected using a five-stage cascade impactor at six sites in the winters of 2005–06. The results of size distribution indicate that a major portion (~40%) of TSPM concentration is in the form of PM0.7 (<0.7 µm). Similar trends were observed with most of the heavy metals associated with various size fractions of TSPM. A very good correlation between coarse and fine size fraction of TSPM was observed. It was also observed that the metals associated with coarse particles have more chances of correlation with other metals; rather they are associated with fine particles. Source apportionment was carried out separately in coarse and fine size modes of TSPM by Chemical Mass Balance Receptor Model (CMB8) as

well as by Principle Component Analysis (PCA) of SPSS. Source apportionment by PCA reveals that there are two major sources (possibly vehicular and crustal re-suspension) in both coarse and fine size fractions. Results obtained by CMB8 show the dominance of vehicular pollutants and crustal dust in fine and coarse size mode respectively. Noticeably the dominance of vehicular pollutants are now confined to fine size only whilst during pre CNG era it dominated both coarse and fine size mode. An increase of 42.5, 44.4, 48.2, 38.6 and 38.9% in the concentrations of TSPM, PM10.9, coarse particles, fine particles and lead respectively was observed during pre (2001) to post CNG (2005-06) period.

Atmospheric Research, Volume 92, Issue 1, March 2009, Pages 88–99

http://www.sciencedirect.com/science/article/pii/S016980950800241X

A study to characterize the influence of outdoor SPM and associated metals on indoor environment in Delhi

Arun Srivastava, V. K. Jain

ABSTRACT

In order to understand the influence of outdoor SPM and its associated metals on indoor environment, a study was carried out for 24 residential, sensitive, commercial and heavy traffic sites in Delhi. In the first phase, the samplings of SPM were conducted simultaneously indoors and outdoors at a reference site during February to March 2000 and later at all other sites from February to July 2001. Atomic Absorption Spectrometry (AAS) was used to determine the heavy metal composition of SPM, analyses of Ca, Mg, Cu, Cd, Pb, Cr, Mn, Fe and Ni were done. It is observed that, depending upon the nature of the site, the outdoor SPM concentrations affect the indoor SPM concentrations in varying degrees. In case of metals such as Cu, Cr, Cd and Ni, very good correlation between the indoor and outdoor concentrations was observed irrespective of the nature of the site. The correlation between indoor and outdoor for Mg, Fe, Mn and Pb depends upon the nature of the site. No correlation was observed between indoor and outdoor Ca at any of the chosen sites.

Journal of Environmental Science & Engineering [2005, 47(3):222-231]

http://europepmc.org/abstract/med/16841462

Traffic-related aerosol exposure and their risk assessment of associated metals in Delhi, India

Rajesh Kushwaha, Arun Srivastava, Himanshu Lal, V. K. Jain

ABSTRACT

A pilot study was carried out in New Delhi, India, to assess the level of traffic related aerosol exposure, individually and associated metals. These investigations also try to formulate their risk assessment using different modes of transport on a typical journey to work route and compared Bus, Auto-rickshaws and Bike (Two Wheelers) during the journey. The inhalable particulate matter monitored in winter period and also evaluated the potential health risk due to inhalation in the study. The exposure of Particulate matter was observed maximum in the Bike (502 ± 176.38 μgm^{-3}) and minimum in the Auto-rickshaw (208.15 ± 61.38 μgm^{-3}). In case of human exposure to metals (viz. Cu, Cd, Mn, Pb, Ni, Co, Cr, Fe, Zn), it was mostly exposed by Fe, Zn and Co and least exposed by Cd, Cr and Pb. Human health risk was estimated based on exposure and dosage response. The assessment of particulate-bound elements was calculated by assuming exposure of 6 h. The findings indicated that the exposure to particulate bound elements have relatively more adverse health effects.

International Journal of Environment, Volume-2, Issue-1, Sep-Nov 2013, Pages 26-36

http://www.nepjol.info/index.php/IJE/article/view/9205

Synergistic Approach for the Aerosol Monitoring and Identification of Types over Indo-Gangetic Basin in Pre-Monsoon Season

Amit Kumar Mishra, Takashi Shibata, Arun Srivastava

ABSTRACT

Aerosol optical and microphysical properties were studied at two major industrial cities (Delhi and Kanpur) of the Indo-Gangetic Basin (IGB) during three (2007–2009) consecutive pre-monsoon (PrM: March–May) seasons, using synergetic analyses of CALIOP, MODIS, AERONET and PARASOL observations. CALIOP-derived aerosol properties show vertically elevated aerosol profiles (up to 4 km altitude), majorly consisting of dust particles during all three PrM seasons with maximum loading in May, 2008. The above inference is well corroborated with columnar aerosol properties from MODIS and AERONET observations. The results also show higher aerosol optical depth (AOD) over Delhi as compared to Kanpur. The high aerosol loading found during the late PrM season at both locations can be attributed to the fact that dust/burning activities are at their peak in May during the PrM season over the IGB. The analyses of optical and microphysical parameters coupled with backward trajectory analyses indicate the presence of three different aerosol types (Type I, Type II and Type III) over both cities during PrM 2009. Type I is characterized as dust-dominated aerosols coming via long-range transportation from major dust sources (desert of Sahara, Iran, Afghanistan and western India), whereas a mixture of absorbing aerosols and dust coming from the Arabian Peninsula and the Thar Desert is characterized as Type II aerosols. The presence of highly absorbing, fine mode dominated Type III aerosols are categorized as urban-industrial/biomass burning aerosols, mainly locally originated and/or influenced by agriculture fires in the Himalayan foothills. A combination of CALIOP and PARASOL observations with ground-based measurements also highlights the dominance of biomass burning smoke (mixed with polluted continental) over the IGB during the middle of May in 2009. The variability in aerosol types found during the PrM season indicates the significant effect of natural/human activities, associated with different meteorological conditions, on aerosol behavior over the region.

Aerosol and Air Quality Research, Vol. 14, No. 3, April 2014, Pages 767-782

http://aaqr.org/Doi.php?id=17_AAQR-13-03-OA-0083

Review of bioaerosols in indoor environment with special reference to sampling, analysis and control mechanisms

Bipasha Ghosh, Himanshu Lal, Arun Srivastava

ABSTRACT

Several tiny organisms of various size ranges present in air are called airborne particles or bioaerosol which mainly includes live or dead fungi and bacteria, their secondary metabolites, viruses, pollens, etc. which have been related to health issues of human beings and other life stocks. Bio-terror attacks in 2001 as well as pandemic outbreak of flue due to influenza A H1N1 virus in 2009 have alarmed us about the importance of bioaerosol research. Hence characterization i.e. identification and quantification of different airborne microorganisms in various indoor environments is necessary to identify the associated risks and to establish exposure threshold. Along with the bioaerosol sampling and their analytical techniques, various literatures revealing the concentration levels of bioaerosol have been mentioned in this review thereby contributing to the knowledge of identification and quantification of bioaerosols and their different constituents in various indoor environments (both occupational and non-occupational sections). Apart from recognition of bioaerosol, developments of their control mechanisms also play an important role. Hence several control methods have also been briefly reviewed. However, several individual levels of efforts such as periodic cleaning operations, maintenance activities and proper ventilation system also serve in their best way to improve indoor air quality.

Environment International, Volume 85, December 2015, Pages 254–272

http://www.sciencedirect.com/science/article/pii/S0160412015300581

Source identification and metallic profiles of size-segregated particulate matters at various sites in Delhi

Naba Hazarka, V.K. Jain, Arun Srivastava

ABSTRACT

A study of elemental composition in the ambient air of Delhi was carried out in the monsoon, winter and summer seasons at four different sites from August 2012 to April 2013 in the size ranges <1, 1–2.5, 2.5–10 and >10 μm using "Dekati PM10" impactor. At each site, three samples were collected and were analyzed by energy-dispersive X-ray fluorescence (EDXRF). The presence of elements was found to be very common and highly concentrated in aerosol particles at all the sites, which are Na, Al, Si, K, Ca, Zn and Ba. Total suspended particulate matters (TSPMs) of fine particles were found high in comparison to coarse particles at all seasons. The TSPM of fine particles was found to be varied in the range from 303.6 to 416.2 μg/m^3. Similarly, the range of coarse TSPM was observed from 162.9 to 262.8 μg/m^3. Correlation matrices were observed between fine (size ranges <1 and 1–2.5 μm) and coarse (size ranges 2.5–10 and >10 μm) size particles for all elements with seasons. Source apportionments of elements were carried out using MS Excel 2010 through XLSTAT software. The source apportionments between fine and coarse particles were carried out through factor analysis and dominated sources found to be crustal re-suspension and industrial activities.

Environmental Monitoring and Assessment, September 2015, 187:602
http://link.springer.com/article/10.1007/s10661-015-4809-7

Influence of seasonal variation on concentration of fungal bioaerosol at a Sewage Treatment Plant (STP) in Delhi

Sunita Maharia, Arun Srivastava

ABSTRACT

Ambient levels of viable bioaerosol (fungi) were measured at six different sections of a sewage treatment plant in Vasant Kunj, New Delhi. The sampling was carried out for fungal fractions of bioaerosols during the month of June 2012 to May 2013 covering all the four seasons of India, i.e., monsoon, post-monsoon, winter, and pre-monsoon. Sampling was done thrice in a month with the help of a six-stage viable cascade impactor for 10 min each at a flow rate of 28.3 l min^{-1}. Temperature and relative humidity were also recorded during each sampling. It was found that among all the six sites, maximum and minimum fungal concentrations were 1,200 and 829 CFU m^{-3} in pre-monsoon; 1,198 and 802 CFU m^{-3} in monsoon; 1,289 and 868 CFU m^{-3} in post-monsoon; and 516 and 279 CFU m^{-3} in winter seasons, respectively. A good regression of fine over coarse fungal bioaerosols was observed in all the four seasons. In total, eight genera of fungi were identified, and among the eight genera identified, four, e.g., *Mucor*, *Rhizopus*, *Aspergillus,* and *Penicillium,* were found in maximum number during all the seasons. This study has revealed interesting results in context to the relationship between concentrations of fungal bioaerosols and environmental factors as well as interparticle size relationship of fungal bioaerosols.

Aerobiologia June 2015, Volume 31, Issue 2, pp 249-260
http://link.springer.com/article/10.1007/s10453-014-9361-3

Human Exposure to Particulate Matter and Their Risk Assessment over Delhi, India

Rajesh Kushwaha, Himanshu Lal, Arun Srivastava, Vinod K Jain

ABSTRACT

Human exposure to particulate matter was determined in the urban environment of Delhi. Monitoring was done on an 8 h exposure basis. Samples were collected using an eight stages impactor (Marple Cascade Impactor) at five sites during December 2010 to March 2011. Fifteen samples were collected and each stage samples were analyzed gravimetrically and chemically (for metals). The maximum (2,118.45 μg/m^3) exposure due to particulate matter (PM) was at Okhala, an industrial site and the minimum (490.17 μg/m^3) in Jawaharlal Nehru University an educational Institute. Exposure due to metals (viz. Cu, Cd, Mn, Pb, Ni, Co) at the five locations was mostly

dominated by Pb, Mn, Ni and least dominated by Cd,Cu and Co. Okhala was most polluted area and Jawaharlal Nehru University (forest area, out of industrial and commercial hub) the least. Pb, Ni, Co were dominant metal aerosols of Okhala, while Kaushambi, being fully residential area but located near waste site and national highway, was rich in Pb, Mn and Ni. Pb concentration exceeded government guideline.

National Academy Science Letters, December 2012, Volume 35, Issue 6, pp 497-504

http://link.springer.com/article/10.1007/s40009-012-0085-z

Applying SEM-EDX and XRD Techniques to Demonstrate the Overgrowth of Atmospheric Soot and Its Coalescence with Crystal Silicate Particles in Delhi

Arun Srivastava, Vinod K Jain

ABSTRACT

Scanning electron microscopy-energy dispersive X-ray analysis (SEM-EDX) and X-ray diffraction (XRD) systems were used to demonstrate the overgrowth of soot to fractal like structure and its subsequent coalescence with crystal shaped silicate particles. Sample was obtained from a very clean area of Delhi at a height of 16 m from ground with the help of a five stage cascade impactor in the winters of 2006. Impactor collects particles in five different size ranges (i.e. ≥10.9, 10.9 - 5.4, 5.4 - 1.6, 1.6 - 0.7 and ≤0.7 μm). In the present investigation only the particles collected in the size range 1.6 - 0.7 μm (D_{50} = 0.980 μm) have been considered. It has clearly been observed that the soot particles tend to grow or rather agglomerate in a fractal like structure. During this process they incorporate other chemically and structurally different particles (crystal silicate in the present investigation) to make multi phase and multi chemical amorphous aggregates. These aggregates are formed during/after its collection on the sampling substrate and may be as many as hundred times more than the expected size interval (D_{50} or cut off range).

Atmospheric and Climate Sciences, Vol. 2, No. 1 (2012), Article ID: 17130, 5 pages

http://file.scirp.org/Html/10-4700051_17130.htm

SEM-EDX analysis of size segregated particulate matter in Allahabad located in north India

Rajesh Kushwaha, Naba Hazarika, Arun Srivastava

ABSTRACT

Aerosol samples of size ranges $PM_{<1}$, $PM_{1\text{-}2.5}$, $PM_{2.5\text{-}10}$, and $PM_{>10}$ were collected from urban and rural area of Allahabad. The average mass concentration of $PM_{<1}$ was 85.87±37.45 μg/m^3, $PM_{1\text{-}2.5}$ 51.14±9.48 μg/m^3, $PM_{2.5\text{-}10}$ 44.25±15.35 μg/m^3 and $PM_{>10}$ was 46.22±17.03 μg/m^3 at urban site while at rural site it was found $PM_{<1}$ 65.51±20.24 μg/m^3, $PM_{1\text{-}2.5}$ 50.91±9.45 μg/m^3, $PM_{2.5\text{-}10}$ 48.7±6.25 μg/m^3 and $PM_{>10}$ 25.08±14.60 μg/m^3. Scanning electron microscopy-energy dispersive X-ray analysis (SEM-EDX) was used to understand the differences in morphology, elemental composition of particulate matters viz. $PM_{<1}$, $PM_{1\text{-}2.5}$, $PM_{2.5\text{-}10}$, and $PM_{>10}$ respectively. The SEM micrograph, size segregated aerosol was different at the two sites. It was observed that SEM-EDX is a useful method to identify the source of emission of particulate matter. The results revealed concentration of pollution is site specific but largely because of industry, vehicular activities, crustal dust and oil.

International Journal of Advanced Research

http://www.journalijar.com/article/228/sem-edx-analysis-of-size-segregated-particulate-matter-in-allahabad-located-in-north-india/

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Chemical speciation of respirable suspended particulate matter during a major firework festival in India

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ABSTRACT

Ambient respirable particles (PM≤10_m, denoted by PM10) were characterized with respect to 20 elements, 16 polycyclic aromatic hydrocarbons (PAHs), elemental and organic carbon (EC and OC) during a major firework event—the "Diwali" festival in Delhi, India. The event recorded extremely high 24-h PM10 levels (317.2–616.8_gm−3, 6–12 times the WHO standard) and massive loadings of Ba (16.8_gm−3, mean value), K (46.8_gm−3), Mg (21.3_gm−3), Al (38.4_gm−3) and EC (40.5_gm−3). Elemental concentrations as high as these have not been reported previously for any firework episode. Concentrations of Ba, K, Sr, Mg, Na, S, Al, Cl, Mn, Ca and EC were higher by factors of 264, 18, 15, 5.8, 5, 4, 3.2, 3, 2.7, 1.6 and 4.3, respectively, on Diwali as compared to background values. It was estimated that firework aerosol contributed 23–33% to ambientPM10 on Diwali. OC levels peaked in the post-Diwali samples, perhaps owing to secondary transformation processes. Atmospheric PAHs were not sourced from fireworks; instead, they correlated well with changes in traffic patterns indicating their primary source in vehicular emissions. Overall, the pollutant cocktail generated by the Diwali fireworks could be best represented with Ba, K and Sr as tracers. It was also found that chronic exposure to Diwali pollution is likely to cause at least a 2% increase in non-carcinogenic hazard index (HI) associated with Al, Mn and Ba in the exposed population.

Journal of Hazardous Materials, Volume 184, Issues 1–3, 15 December 2010, Pages 321–330

http://www.sciencedirect.com/science/article/pii/S0304389410010551

Impact of CNG implementation on PAHs concentration in the ambient air of Delhi: A comparative assessment of pre- and post-CNG scenario

P. S. Khillare & Tripti Agarwal & Vijay Shridhar

ABSTRACT

The use of alternative fuel is considered to be an effective measure to improve the urban air quality. Concerned over deteriorating air quality in Delhi, the Delhi government initiated different measures including stringent emission norms, improved fuel quality and above all introduction of cleaner fuel-CNG in public transport system. The entire city bus fleet was converted to CNG mode by 2002. The present study reports the comparative assessment of the status of air quality with respect to PM10 and PAH before and after the introduction of CNG in public transport system in Delhi. The study has been carried out for two different time periods: first in the year 1998 and second in the year 2004. Following the total conversion of public transport system to CNG in 2002, Post-CNG data indicate a sharp reduction of 51–74% in the PM10 concentration and 58–68% in the TPAH concentration as compared to the Pre-CNG data.

Environmental Monitoring and Assessment, December 2008, Volume 147, Issue 1, pp 223-233

http://link.springer.com/article/10.1007%2Fs10661-007-0114-4

Metallic species in ambient particulate matter at rural and urban location of Delhi

Vijay Shridhar, P.S. Khillare, Tripti Agarwal, Sharmila Ray

ABSTRACT

In the present study 14 metallic species (six crustal and eight trace metals) were quantified in the suspended particulate matter (SPM) at a rural and urban location of Delhi, India. Particulate matter was collected on glass fiber filters for a period of one year (from September 2003 to August 2004). Rank sum test revealed that the TSP

concentration at the urban site was significantly (P = 0.47) higher as compared to the rural site. Urban site showed highest SPM concentration during winter while rural site during summer. Enrichment factor (EF) and coefficient of variation (CV) were calculated to assess the variability of elemental concentration data. Trace metals viz. Pb, Cd, Cu and Zn were observed to be highly enriched at both the sites, but EF for Zn and Cu was 2–3 times higher at the urban site as compared to the rural site. Trace and crustal metal concentration displayed less variability at the urban site. In the urban area, metals were mainly found to come from construction and industrial activities in surrounding. At the rural site, re-suspended and wind-blown dust appeared to be the source of observed elemental concentration.

Journal of Hazardous Materials, Volume 175, Issues 1–3, 15 March 2010, Pages 600–607
http://www.sciencedirect.com/science/article/pii/S0304389409016859

Occurrence of acid rain over delhi

S. Balachandran and p. S. Khillare

ABSTRACT

Precipitation samples were collected as wet-fall only and primarily on event basis in Delhi during the monsoon period of 1995. Concentrations of major anions (SO_4^{2-}, NO_3^- and Cl^-) and cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) were determined. The pH of the rain water was found to be more than 5.6, showing alkalinity during the early phase of monsoon, but during the late phase of monsoon pH tendency was towards acidity due to lack of proper neutralization of acidic ions. Neutralization is not only due to the local process but also due to the pre-monsoon 'Andhi' which brings Suspended Particulate Matter (SPM) containing Ca^{2+}, Mg^{2+}, Na^+ and K^+ as well as the local emission of NH_3. In the late monsoon the concentration of cations gets reduced because of heavy rainfall and relatively unfavourable condition for their transport from the adjoining areas, whereas the anion concentrations remain unchanged owing to their continuous emission.

Environmental Monitoring and Assessment, October 2001, Volume 71, Issue 2, pp 165-176
http://link.springer.com/article/10.1023%2FA%3A1017541809985

Particle size distribution and its elemental composition in the ambient air of Delhi

S. Balachandran, Bharat Raj Meena, P.S. Khillare

ABSTRACT

This study examines the chemical composition of PM10, the thoracic fraction of the atmospheric particulate matter. An eightstage Anderson impactor is used to separate the PM10 from other fractions with different aerodynamic behaviour at three different area representative sites in Delhi from February to May 1998. PM10 particulate are subdivided into two fractions, coarse (.2.1–10 mm) and fine (,2.1 mm). The concentrations of major heavy metals such as Pb, Zn, Cd, Ni, and Fe are determined by atomic absorption spectrophotometer. The average concentration of coarse fraction of PM10 is found to be 68.3 6 17 mg/m3 while the fine fraction of PM10 is 71.3 6 15 mg/m3 for Delhi. Metal concentration (except Fe) in fine fraction exceeds by a factor of up to 6, as compared to that in the coarse fraction. In order to identify the major sources of fine and coarse fraction of PM10, principle component analysis (PCA) was undertaken and three major sources were identified, namely vehicular emissions, industrial emission, and soil resuspension.

Environment International, Volume 26, Issues 1–2, August 2000, Pages 49–54
http://www.sciencedirect.com/science/article/pii/S0160412000000775

Profile of PAH in the exhaust of gasoline driven vehicles in Delhi

P. S. Khillare, S. Balachandran and Raza Rafiqul Hoque

ABSTRACT

A preliminary study to determine the profile of PAHs in the exhaust of gasoline vehicles in Delhi was conducted. Three different types of vehicles (cars, autorickshaws and scooters) were selected with different age groups for sampling purpose. The concentration of Total PAHs (_12PAHs) was found to be 27.27 ± 2.27, 28.61 ± 3.70 and 29.81 ± 3.57 mg/g in the exhaust of cars, autorickshaws (three wheelers) and two wheelers, respectively. The levels of PAHs were found to be high in scooter exhaust as compared to that of cars and autorickshaws. The total PAHs concentration in the present study was found to be higher as compared to other studies. Such a high concentration could be attributed to different parameters like the age of the vehicles, driving conditions, the fuel quality and the emission standards.

Environmental Monitoring and Assessment, November 2005, Volume 110, Issue 1, pp 217-225
http://link.springer.com/article/10.1007/s10661-005-7865-6

Profile of PAHs in the Diesel Vehicle Exhaust in Delhi

P. S. Khillare, S. Balachandran And Raza Rafiqul Hoque

ABSTRACT

A preliminary study to determine the profile of PAHs in the exhaust of diesel vehicles plying on Delhi roads was conducted. Two different types of diesel vehicles (buses and trucks) with different age groups were selected for sampling purpose. The concentration of Total PAHs (_12PAHs) was found to be 50.76±6.62 and 57.72±4.15 mg/g in the exhaust of buses and trucks, respectively. The levels of PAHs were found to be high in trucks as compared to that of buses. The total PAHs concentration in the present study was found to be higher as compared to other studies. Such a high concentration could be attributed to different parameters like the age of the vehicles, driving conditions, the fuel quality and the emission standards.

Environmental Monitoring and Assessment, June 2005, Volume 105, Issue 1, pp 411-417
http://link.springer.com/article/10.1007/s10661-005-4438-7

Spatial and temporal variation of BTEX in the urban atmosphere of Delhi, India

Raza Rafiqul Hoque, P.S. Khillare, Tripti Agarwal, Vijay Shridhar, S. Balachandran

ABSTRACT

Benzene, toluene, ethylbenzene and xylene (BTEX) form an important group of aromatic Volatile Organic Compounds (VOCs) because of their role in the tropospheric chemistry and the risk posed by them to human health. Concentrations of BTEX were determined at different sampling points in the ambient air of Delhi in order to investigate their temporal and spatial distributions. Significant positive correlation coefficient (pb0.01) was found between inter-species concentrations at all the sampling locations. Inter-species ratio and Pearson's correlations indicate that gasoline vehicular exhaust could be the major source of BTEX in Delhi. The inter-species ratios exhibit clear seasonal variations indicating differential reactivity of the VOC species in different seasons. Xylenes were found the largest contributor to the ozone formation followed by toluene.

Science of The Total Environment, Volume 392, Issue 1, 15 March 2008, Pages 30–40
http://www.sciencedirect.com/science/article/pii/S0048969707009084

Spatial and temporal variation of heavy metals in atmospheric aerosol of Delhi

P. S. Khillare, S. Balachandran and Bharat Raj Meena

ABSTRACT

The levels of Suspended Particulate Matter (SPM) and heavy metals viz. Pb, Cd, Cr, Ni and Fe were measured. Aerosol samples from four different locations in Delhi were collected by High-volume samplers for a period of one year from July 1997 June 1998. Metal concentration was determined by Atomic Absorption Spectrometry. The annual average concentration of SPM in Delhi was found to be 416.34 ± 223 μg m−3. The atmospheric aerosol samples were highly enriched with elements viz. Pb and Cd, which originate from various human activities like transportation and industrial processes. Principal Component Analysis (PCA) showed vehicular traffic and industrial emission as the major contributors of metals. The annual average concentration of Pb did not exceed the national standard of 0.75 μg m−3.

Environmental Monitoring and Assessment, January 2004, Volume 90, Issue 1, pp 1-21
http://link.springer.com/article/10.1023%2FB%3AEMAS.0000003555.36394.17

Temporal variability of benzene concentration in the ambient air of Delhi: A comparative assessment of pre- and post-CNG periods

P.S. Khillare, Raza Rafiqul Hoque, Vijay Shridhar, Tripti Agarwal, S. Balachandran

ABSTRACT

CNG (compressed natural gas) was fully implemented in public transport system in Delhi in December 2002. The study assesses the benzene concentration trends at two busy traffic intersections and a background site in Delhi, India. Monitoring was done for two different time periods viz; in the year 2001–2002 (pre-CNG) and two winter months (January and February) of the year 2007 (post-CNG) to assess the impact of various policy measures adopted by the government of Delhi to improve the air quality in the city. Annual average benzene concentration for the pre-CNG period was found to be 86.47±53.24_gm−3. Average benzene concentrations for the winter months (January–February) of pre- and post-CNG periods were 116.32±51.65_gm−3 and 187.49±22.50_gm−3, respectively. Enhanced values could be solely attributed to the increase in the vehicular population from 3.5 million in the year 2001–2002 to ~5.1 millions in the year 2007.

Journal of Hazardous Materials, Volume 154, Issues 1–3, 15 June 2008, Pages 1013–1018
http://www.sciencedirect.com/science/article/pii/S0304389407016081

Visibility impairing aerosols in the urban atmosphere of Delhi

Tejveer Singh, P. S. Khillare, Vijay Shridhar, Tripti Agarwal

ABSTRACT

To study the visual air quality of Delhi, size fractionated aerosols – coarse and fine fractions of PM_{10} – were collected and analysed for SO_4^{2-}; NO_3^-; NH_4^+; OC and EC at three sites with different background activities. The analysed species constitute a smaller portion of coarse fraction (39%) but a larger portion of fine fraction (69%). The sampling was performed from June 2003 to November 2003 which covers monsoon and post monsoon seasons. Aerosol data was used to describe the spatial variation of Visibility Range as a function of chemical composition of visibility impairing aerosols. During the study period, visibility was found to be poor varying between 4.7 and 13 km with an average value of 9.4 km. It is observed that visibility impairment was more due to carbonaceous aerosol followed by sulphate.

Environmental Monitoring and Assessment, June 2008, Volume 141, Issue 1, pp 67-77
http://link.springer.com/article/10.1007/s10661-007-9879-8

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Air quality and trace metal chemistry of different size fractions of aerosols in N–NW India—implications for source diversity

Sudesh Yadav, V. Rajamani

ABSTRACT

Three different size fractions of aerosols free fall (FF), suspended particulate matter (SPM) and particles less than 10 mm (PM10) as well as surface sediments were collected from four different locations situated along a dust transport path of nearly 600km in NW India starting from Bikaner in the Thar to Garhmuktesar through Jhunjhunu and Delhi and were studied for their heavy-metal chemistry. NW India is characterized by hot arid to semiarid climate with prevailing S–SW winds causing dust storms in summer and low intensity N–NW winds during winter months. The aerosol load in the atmosphere increased to several orders of magnitude for all size ranges (FF = 21 gm^{-2} day^{-1}; SPM = 10,702µgm^{-3} and PM_{10} = 2907µgm^{-3}) during the summer dust storm period compared to national air quality standards as well as to the aerosol load in winter. Aerosol sources are dominantly crustal with a significant anthropogenic contribution during the winter. We also note multiplicity of sources for the heavy metals studied here. Sr, V and Cr are dominantly crustal. Ba and Pb are added largely by fossil fuel burning; Cu, Ni and Zn are contributed by various industries. Anthropogenically added heavy metals show maximum enrichment relative to the upper continental crustal component in finer fractions and especially in winter. We suggest that the aerosol loading in the atmosphere and its heavy-metal chemistry is strongly influenced by the climatic regime and the presence of desert and industrialization in this area.

Atmospheric Environment, Volume 40, Issue 4, February 2006, Pages 698–712

http://www.sciencedirect.com/science/article/pii/S1352231005009313

Characterisation of bio-aerosols during dust storm period in N–NW India

Sudesh Yadav, M.S. Chauhan, Anupam Sharma

ABSTRACT

Bio-investigations for pollen and spores were performed on dry free-fall dust and PM10 aerosol samples, collected from three different locations separated by a distance of 600 km, situated in dust storm hit region of N–NW India. Presence of pollen of trees namely Prosopis (Prosopis juliflora and Prosopis cinearia), Acacia, Syzygium, Pinus, Cedrus, Holoptelea and shrubs namely Ziziphus, Ricinus, Ephedra and members of Fabaceae, Oleaceae families was recorded but with varying proportions in the samples of different locations. Poaceae, Chenopodiaceae/Amaranthaceae, Caryophyllaceae, Brassicaceae and Cyperaceae (sedges) were some of the herb pollen identified in the samples. Among the fungal spores Nigrospora was seen in almost all samples. Nigrospora is a well known allergen and causes health problems. The concentration of trees and shrubs increases in the windward direction just as the climate changes from hot arid to semiarid. The higher frequency of grasses (Poaceae) or herbs could either be a result of the presence of these herbs in the sampling area and hence the higher production of pollen/spores or due to the resuspension from the exposed surface by the highintensity winds. But we cannot ascertain the exact process at this stage. The overall similarity in the pollen and spore assemblage in our dust samples indicates a common connection or source(s) to the dust in this region. Presence of the pollen of the species of Himalayan origin in our entire samples strongly point towards a Himalayan connection, could be direct or indirect, to the bioaerosols and hence dust in N–NW India. In order to understand the transport path and processes involved therein, present study needs further extension with more number of samples and with reference to meteorological parameters.

Atmospheric Environment, Volume 41, Issue 28, September 2007, Pages 6063–6073

http://www.sciencedirect.com/science/article/pii/S1352231007002348

Factors and sources influencing ionic composition of atmospheric condensate during winter season in lower troposphere over Delhi, India

Pawan Kumar & Sudesh Yadav

ABSTRACT

Atmospheric condensate (AC) and rainwater samples were collected during 2010–2011 winter season from Delhi and characterized for major cations and anions. The observed order of abundance of cations and anions in AC samples was NH_4^+>Ca^{2+}>Na^+> K^+>Mg^{2+} and HCO_3^->SO_4^{2-}>Cl^->NO_2^->NO_3^-> F^-, respectively. All samples were alkaline in nature and $\Sigma_{cation}/\Sigma_{anion}$ ratio was found to be close to one. $NH4^+$ emissions followed by Ca^{2+} and Mg^{2+} were largely responsible for neutralization of acidity caused by high NO_x and SO_2 emissions from vehicles and thermal power plants in the region. Interestingly, AC samples show low nitrate content compared with its precursor nitrite, which is commonly reversed in case of rainwater. It could be due to (1) slow light-mediated oxidation of HONO; (2) larger emission of NO2 and temperature inversion conditions entrapping them; and (3) formation and dissociation of ammonium nitrite, which seems to be possible as both carry close correlation in our data set. Principal component analysis indicated three factors (marine mixed with biomass burning, anthropogenic and terrestrial, and carbonates) for all ionic species. Significantly higher sulfate/nitrate ratio indicates greater anthropogenic contributions in AC samples compared with rainwater. Compared with rainwater, AC samples show higher abundance of all ionic species except SO_4, NO_3 , and Ca suggesting inclusion of these ions by wash out process during rain events. Ionic composition and related variations in AC and rainwater samples indicate that two represent different processes in time and space coordinates. AC represents the near-surface interaction whereas rainwater chemistry is indicative of regional patterns. AC could be a suitable way to understand atmospheric water interactions with gas and solid particle species in the lower atmosphere.

Environmental Monitoring and Assessment, March 2013, Volume 185, Issue 3, pp 2795-2805
http://link.springer.com/article/10.1007/s10661-012-2749-z

Source apportionment and spatial–temporal variations in the metal content of surface dust collected from an industrial area adjoining Delhi, India

Aditya Kumar Pathak, Sudesh Yadav, Pawan Kumar, Rakesh Kumar

ABSTRACT

Surface dust collected during three different seasons from Faridabad industrial area adjoining Delhi is studied for different metals, their spatial and temporal variations, and sources. Al, Fe, Mn, Ti, Ca and Mg show limited variations and lower abundances compared to Upper Continental Crust (UCC); Fe shows enrichment and seasonal changes. Cd, V, Co, Ba, Ti, Ni, Cu, Cr and Zn show significant spatial and temporal variations, and enrichments compared to UCC indicate their anthropogenic sources. Seasonal variability could be due to: 1) different types of industries, 2) variations in the emissions, 3) very frequent shifting of small scale industry within the region, and 4) changes in the land use pattern. The sampling sites, according to the geo-accumulation index, are: 1) least polluted for Ca, Mg, Al and Ti except for Ti in winter, 2) least to moderately polluted for Ba, Co and V but season specific, and 3) moderately to extremely polluted for other metals. Average pollution load index of 2.67–2.87 indicates consistently high level of pollution at all sites in all sampling seasons. The sites located in the residential areas near small to medium scale unorganized industry are more polluted compared to sites near large industries suggesting that the small scale unorganized industries causes more pollution. Three dominant sources of metals were identified: 1) mixed industrial, 2) crustal, and 3) vehicular, oil and battery related burnings. The third component related to Ba, Pb, Cd, Zn and Cr, further splits into two components in the pre-monsoon and winter samples. Surface dust, enriched in metals, is likely to cause serious danger to public health. There is an urgent need to make a shift from unorganized to formally organized industry to reduce themetal pollution and protect human health and environment as a whole.

Science of The Total Environment, Volume 443, 15 January 2013, Pages 662–672
http://www.sciencedirect.com/science/article/pii/S0048969712014544

Sources and processes governing rainwater chemistry in New Delhi, India

Pawan Kumar, Sudesh Yadav, Abhay Kumar

ABSTRACT

Rainwater plays an important role in scavenging of aerosols and gases from atmosphere, and its chemistry helps to understand the relative contributions of atmospheric pollution sources. The present work is aimed to understand and explain the sources, seasonal patterns and the processes thereof affecting rainwater chemistry in an urban environment of Delhi, India. Rainwater samples (n = 111) collected throughout the year in New Delhi showed alkalinity in general. Eight rainwater samples, collected in late monsoon and winter season, had pH less than 5.6 indicating that Delhi continues to face the prospects of acid rain despite the introduction of compressed natural gas as the clean fuel in city transport. Organic acids could be the possible contributors of acidity in rainwater samples having the fractional acidity (FA) value of 0.174, which is greater than the annual average FA (0.011) and the $(Ca^{2+} + Mg^{2+} + NH4^{+})/(SO_4^{2-} + NO_3^{-})$ ration of more than one. Average acid neutralization factors of cations decrease in the order Ca^{2+} (1.01) > NH_4^{+} (0.77)[Mg^{2+} (0.10). However, neutralization by Ca^{2+} dominates only in summer season as cation-rich dust is transported from the Great Indian Thar Desert to this region by strong summer S–SW winds, while NH_4^{+} dominates in rainwater of other three sampling seasons. Identified dominant sources for soluble ions in rainwater are (1) nonsilicate crustal source for carbonates and sulfates of Ca and Mg, (2) emissions from catalytic convertor-fitted vehicles and agriculture fields for NH_3 and (3) mixed anthropogenic sources for SO_4^{2-}, NO_3^{-} and Cl^{-}. Rainwater chemistry showed significant seasonal variations. This could be due to the changes in relative proportions of natural and anthropogenic sources of soluble ions to rainwater. Dominance of anthropogenic sources over crustal sources can result in acidic rains, which can adversely affect the environment and human health in this region.

Natural Hazards, December 2014, Volume 74, Issue 3, pp 2147-2162
http://link.springer.com/article/10.1007/s11069-014-1295-0

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Abundance and distribution of gaseous ammonia and particulate ammonium at Delhi, India

S. Singh and U. C. Kulshrestha

ABSTRACT

This study reports abundance and distribution of gaseous NH_3 and particulate NH_4^{+} at Delhi. Gaseous NH_3 and particulate NH_4^{+} concentrations were measured during pre-monsoon, monsoon and post-monsoon seasons of the years 2010 and 2011. Average concentrations of gaseous NH_3 during pre-monsoon, monsoon and post-monsoon seasons were recorded as 26.4, 33.2 and 32.5 μgm^{-3}, respectively. Gaseous NH_3 concentrations were the highest during monsoon, thought to be due to decay and decomposition of plants and other biogenic material under wet conditions, leading to increased NH_3 emission. The results showed that particulate NH_4^{+} was always lower than the gaseous NH3 during all the seasons. The concentrations of particulate NH_4^{+} were recorded as 11.6, 22.9 and 8.5 μgm^{-3} during pre-monsoon, monsoon and post-monsoon seasons, respectively. The percent fraction of particulate NH_4^{+} was noticed to be highest during the monsoon season, which is attributed to increased humidity levels favouring partitioning into the aerosol phase. On an average, 33.3% of total N-NH_x was present as particulate NH_4^{+}. Higher concentrations of NH_3 noticed during night time may be due to stable atmospheric conditions. The study highlighted that, as compared with rural sites, urban sites showed higher concentrations of gaseous NH_3 in India, which may be due to higher population density, human activities and poor sanitation arrangements.

Biogeosciences, Vol. 9, Issue:12, 5023-5029, 2012
http://www.biogeosciences.net/9/5023/2012/bg-9-5023-2012.html

Applications of Air Mass Trajectories

Isidro A. Pérez, Florinda Artuso, Mastura Mahmud, Umesh Kulshrestha, M. Luisa Sánchez, and M. Ángeles García

ABSTRACT

Air trajectory calculations are commonly found in a variety of atmospheric analyses. However, most of reported research usually focuses upon the transport of pollutants via trajectory routes and not on the trajectory itself. This paper explores the major areas of research in which air trajectory analyses are applied with an effort to gain deeper insights into the key points which highlight the necessity of such analyses. Ranging from meteorological applications to their links with living beings, air trajectory calculations become important tool especially when alternative procedures do not seem possible. This review covers the reports published during last few years illustrating the geographical distribution of trajectory applications and highlighting the regions where trajectory application research proves most active and useful. As a result, relatively unexplored areas such as microorganism transport are also included, suggesting the possible ways in which successful use of air trajectory research should be extended.

Advances in Meteorology, Volume 2014 and 2015
http://www.hindawi.com/journals/amete/si/803962/

Coping with Climate Change: Principles and Asian Context

Ramesha Chandrappa, Sushil Gupta, Umesh Chandra Kulshrestha

About this book: The Environmental and climatic issues varies from continent to continent and is unique to Asia. Understanding the issues does need lot of research and study material which students may not be able to gather due to shortage of time and resources. Hence an effort is made by authors gathering there experience and academic input from renowned universities of world. Climate change is real and coping with it is major concern in coming days. Most of the books written and sold in the past need updating and customizing. The general description of climate change and world will not help the professionals and students. It needs to seen area wise as a professional will work in specific geographic area. Hence an effort is made to collect data from Asia which host most populated countries along with ecological hot spots.

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http://www.springer.com/cn/book/9783642196737

Deposition and Impact of Urban Atmospheric Dust on Two Medicinal Plants during Different Seasons in NCR Delhi

Gyan Prakash Gupta, Bablu Kumar, Sudha Singh, Umesh Chandra Kulshrestha

ABSTRACT

This study reports dustfall deposition on foliar surfaces of two medicinally important plant species i.e., Arjun (*Terminalia arjuna*) and Morus (*Morus alba*) in relation with its impact on biochemical constituents and surfaces morphology of the foliar. The study was carried out at a residential (JNU) and an industrial site (SB) of National Capital Region (NCR) Delhi. The results showed that at the industrial site, the dustfall fluxes were almost 2.5 times higher than that at the residential site. Dustfall fluxes were noticed higher on Morus foliar than Arjun foliar as the roughness of Morus foliar is greater. Deposition fluxes of major anions (F^-, Cl^-, NO_3^-, SO_4^{2-}) and cations (Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+}) ions were also calculated by analyzing aqueous extract of dustfall at both the site. The results showed that with the increase in dustfall fluxes on the foliar surfaces, the levels of photosynthetic pigments and soluble sugar decreased while the levels of ascorbic and proline amino acid were increased at both the sites for both the plants. Dustfall fluxes had distinct seasonality having the order of fluxes as winter > summer > monsoon. Surface morphological study revealed that dust deposition adversely affects the foliar surface, cuticle and epidermal layers. Dust particle deposition ruptures and blocks the stomatal pores. As compared to the residential site, the foliar samples collected from the industrial site showed a more significant impact of dust on biochemical constituents and surface morphology.

Aerosol and Air Quality Research, 1–13
http://www.aaqr.org/Doi.php?id=AAQR-15-04-SISEASIA-0272_proof

Global warming-Present status of research and future strategies

Umesh Chandra Kulshrestha

ABSTRACT

Increased fossil fuel combustion, land use changes and deforestation are contributing significant amount of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and other greenhouse gases (GHGs) into the atmosphere. This has resulted in an increase of 0.6°C in global mean surface temperature since the 19th century. Estimates show that at the present rate of GHG increase, this will further increase up to 1.4°C - 5.8°C by 2100. Surprisingly, in the past 100 years, the average temperatures in the Arctic region have increased at almost twice the global rate. It is estimated that combined effect of present increase in CO_2, N_2O and CH_4 would lead to an increase of atmospheric heating by 2.3 W m^{-2}. Calculations show that due to aerosol effect, the observed increase in global mean surface temperature over the industrial era is lesser by 40% of that expected from observed increase in concentrations of major GHGs. A significant part of heating is attributed to absolute nature of black carbon (BC) which contributes radiative forcing of the order of 0.3 to 0.5 W m^{-2}. At the same time, BC and other absorbing aerosols are reported to cause the dimming effect at the rate of ~6 W m^{-2} per decade over India. However, aerosol radiative forcing calculations have huge uncertainties which need to be corrected. Scientific evidences show that due to global warming, Indian region will experience severe consequences such as increased number of extreme events, sea level rise, melting of glaciers etc. Although per capita GHG emissions of India are very low, the total emissions, however, place India at 4th rank. It is to be noted that Indian initiatives to control GHG emissions and to share emission data with global community are highly appreciable. However, there is a great need of taking measures to control GHG emissions through mitigation and adaptation techniques. It is realized that Clean Development Mechanism (CDM) is the best adaptation option for developing countries to participate in emission reduction strategies.

Indian Geophysical Union, Volume 14, No.4, October 2012
http://www.igu.in/Volume_16-4.html

Importance of atmospheric dust in India: Future scope of research

UC Kulshrestha and Disha Sharma

ABSTRACT

Abundance of soil-dust in Indian atmosphere is a natural geo-engineering tool to combat acidification and climate change. Local as well as transported dust contributes to very high loadings of particulate matter which often exceeds the prescribed limits. Alkaline nature of atmospheric dust acts as a scavenger of SO2 and hence, SO2 concentrations are not recorded very high in the ambient air in India. Also, atmospheric dust affects radiative forcing, cloud modification and heath of humans and plants in Indian region. This report highlights that in spite of its great regional importance, investigations about various aspects of atmospheric dust e.g. budget and inventory, long range transport and sources, combined characterization of carbon mixed aerosols and their role in radiative forcing and monsoons need dedicated systematic research efforts.

Indian Geophysical Union, Volume 19, No.2, April 2015
http://www.igu.in/Volume_19-2.htm

Industrial dust sulphate and its effects on biochemical and morphological characteristics of Morus (Morus alba) plant in NCR Delhi

G.P. Gupta, S. Singh, B. Kumar, U.C. Kulshrestha

ABSTRACT

Abundance of CaCO3 rich soil dust is a typical feature of atmospheric environment in the Indian region. During prevailing dry weather conditions, dustfall is deposited onto the foliar surfaces of plant affecting their morphology, stomata and the levels of biochemical constituents. This study reports the chemical characteristics of dustfall, its effect on foliar morphology and biochemical constituents of a medicinal plant (Morus alba) at two sites which are differentiated on the basis of landuse pattern, viz., (i) residential, Jawaharlal Nehru University (JNU), and (ii) industrial, Sahibabad (SB), located in the National Capital Region (NCR) of Delhi. Dustfall was characterized for

major anions (F(-), Cl(-), NO3 (-) and SO4 (--)) and cations (Na(+), NH4 (+), K(+), Mg(++) and Ca(++)). Biochemical parameters such as chlorophyll a, chlorophyll b, total chlorophyll, carotenoid, proline and ascorbic acid were determined in foliar samples. The results showed that the dustfall fluxes of all the major ions were found to be higher at the industrial site (SB) as compared to the residential site (JNU). Foliar analysis revealed that the levels of biochemical parameters were more affected at SB site due to higher levels of dust SO4 (--) contributed by various anthropogenic sources resulting in more stressful conditions affecting the biochemistry of the plant. The possible entry pathways for dust SO4 (--) into foliar cells are also discussed in the paper. It was noticed that the deposition of urban dust was responsible for the damage of trichome, epidermis, cuticle and stomatal guard cells significantly affecting foliar morphology. SB exhibited more damage to these morphological parts suggesting that industrial dust is harmful to the plants.

Environmental Monitoring and Assessment, March 2015, 187:67
http://www.ncbi.nlm.nih.gov/pubmed/25647798

Real-time wet scavenging of major chemical constituents of aerosols and role of rain intensity in Indian region

U.C. Kulshrestha, L.A.K. Reddy, J. Satyanarayana, Monika J. Kulshrestha

ABSTRACT

Real-time simultaneous studies on chemical characteristics of rainwater and PM10 aerosols were carried out to understand the scavenging of major chemical components in Indian region. The concentrations of Ca2þ, NH4þ, SO4 2 _ and NO3_ were observed to be lower in the aerosol samples collected during rain as compared to before and after rain events. The most significant reduction was noticed for Ca2þ (74%) during rain which showed highest scavenging ratio (SR) and indicated that below-cloud scavenging is an effective removal process for Ca2þ in Indian region. Among non-sea salt components, Ca2þ had highest SR at Hyderabad indicating typical characteristics of crustal influence as abundance of calcium carbonate in soil dust has been reported in India. However, the levels of these major chemical components gradually got build-up in due course of time. After rain events, the levels of SO4 2 _ aerosols were noticed to be substantially higher (more than double) within 24 h. In general, scavenging ratios for all components (except Ca2þ, NH4þ and Kþ) were higher over BOB as compared to Hyderabad. The maximum fall in aerosol levels (BR minus AR) was observed during continuous and low intensity rain events that did not allow building up of aerosol concentrations.

Atmospheric Environment, Volume 43, Issue 32, October 2009, Pages 5123–5127
http://www.sciencedirect.com/science/article/pii/S1352231009006098

Urban climate and its effect on biochemical and morphological characteristics of Arjun (Terminalia arjuna) plant in National Capital Region Delhi

Gyan Prakash Gupta, Bablu Kumar, Sudha Singh & U C Kulshrestha

ABSTRACT

This paper reports impacts of urban pollution on the biochemical and morphological characteristics of Arjuna (*Terminalia arjuna*) in particular the effects of urban industrial dustfall deposition on its foliar surface at a residential site (Jawaharlal Nehru University, JNU) and an industrial site (Sahibabad, SB) in Delhi region. Atmospheric dustfall fluxes were estimated for major anions and cations. Morphological analysis of foliar samples was carried out by using the scanning electron microscope. Biochemical parameters, namely chlorophyll a, chlorophyll b, total chlorophyll, carotenoids, total soluble sugar, proline amino acid and ascorbic acid were also analysed in foliar samples. Results showed that the dustfall fluxes of (SO_4^{2-} + NO_3^-) at the industrial site were almost three times higher than that of the residential site. This can be attributed to the emissions of industrial activities and diesel-driven vehicular traffic in the area. It was observed that these elevated fluxes of SO_4^{2-} and NO_3^- had significant impacts on the biochemical constituents of the plant and foliar morphology. Concentrations of chlorophyll and carotenoids were recorded decreasing with increasing dustfall fluxes of (SO_4^{2-} + NO_3^-), whereas proline and ascorbic acid were found to be increasing with the increase in the dustfall fluxes of (SO_4^{2-} +

NO−3) indicating the effect of pollution stress. The study showed that the deposition of dustfall was responsible for damage to stomata and leaf surface morphology, more significantly at the industrial site.

Chemistry and Ecology, Volume 31, Issue 6, pages 524-538, 2015
http://www.tandfonline.com/doi/abs/10.1080/02757540.2015.1043286

Spatial and temporal patterns of air pollutants in rural and urban areas of India

Disha Sharma, U.C. Kulshrestha

ABSTRACT

In this study, we analysed spatial and temporal patterns of Suspended Particulate Matter (SPM) concentrations across India. We have also assessed MODIS-derived aerosol optical depth (AOD) variations to characterize the air quality and relate it to SPM, NO2 and SO2 in different areas. In addition, the pollutant concentrations have been mapped using geospatial techniques. The results indicated significant differences in air pollutant levels across rural and urban areas. In general, districts of central and northern India had relatively higher SPM concentrations compared to southern India. Out of the top ten SPM polluted districts in India, nine were located in the state of Uttar Pradesh (UP). We observed significant correlations between the SPM and AOD at different sites. Although spatial and temporal patterns of NO2 and SO2 matched AOD patterns, the correlation strength (r2) varied based on location. The causes and implications of these findings are presented.

Environmental Pollution, Volume 195, December 2014, Pages 276–281
http://www.sciencedirect.com/science/article/pii/S0269749114003753

Some Facts about Recent Air Pollution Problem in Delhi

Umesh Kulshrestha

ABSTRACT

During past few months, air pollution problem of Delhi has been a matter of discussion at various forums. Common man pays attention to this issue as it involves each one of us. Due to various bottlenecks, as yet the pollution control authorities have no proper solution. The primary reason is that the issue has never been scientifically analyzed and discussed. This note points out those reasons with some facts, which are not known to the public and various stakeholders. The major issues of air pollution in Delhi include i) Trans-boundary pollution and need of Inter-state task force, ii) Atmospheric dust and black carbon are the two major pollutants, iii) Need to present true picture before the public, iv) Need to define new criteria for $PM_{2.5}$, v) Need to debate the present AQI which serves no purpose and vi) High particulate matter protects from acid rain and hence, it is not always bad.

J. Indian Geophysical Research, v.19, no.3, pp: 351-352 (2015)

Sustainable Air Pollution Management: Theory and Practice

Ramesha Chandrappa, Umesh Kulshrestha

ABSTRACT

This work is intended as a textbook on the theory and practice of sustainable air pollution management. The book discusses the fundamental aspects of traditional air pollution topics as well as some more advanced topics (such as atmospheric brown cloud, trans-boundary movement of air pollutants, air transportation of radioactive material, biological air pollutants, etc.). Though much has been written about theory of Air Pollution Management, it is still not practiced in society for a variety of reasons. Having worked at the grass roots level and travelled extensively, the authors have captured useful, cost-effective and successfully implemented practices with their cameras and notebooks. The non-technical issues that are often seen as a hindrance to adopting sustainable solutions due to political, legal and social factors are also addressed to enable readers to understand a different dimension of social problems. Topics covered include selecting a separation process, process description, materials selection logic, implementation etc. Theory, design and operation specifications are also included for each air pollution management option.

Sustainable Air Pollution Management, Environmental Science and Engineering
DOI 10.1007/978-3-319-21596-9_1, ISBN 978-3-319-21596-9

Acid Rain

Umesh Kulshrestha

ABSTRACT

After the industrial revolution, increased emissions of SO_2 and NO_x from fossil fuel combustion have resulted in an acid rain problem. Earlier, acid rain was observed as a common phenomenon in North America and Europe, but recent studies show its spread in East Asia too, covering China, Japan, and Thailand. European data show that most of the acidity was intensified during 1955–1970, with a sudden increase in the mid-1960s. Scandinavia and Central and Southern Germany were among the worst-hit areas, whereas northeastern United States and southeastern Canada were the most affected areas in North America. Acid rain resulted in loss of fish population in the lakes of Sweden, parts of southwest Norway, and eastern North America. In parts of Germany and other European countries, forest damage and loss of needles from pine and spruce trees was noticed. Beginning with the 1972 Conference on the Human Environment in Stockholm, successful efforts have been made by North America and Europe to control acid rain through $SO_2$and NO_xemission control policies under various national and international cooperative programs. However, in the developing countries, SO_2 emissions are still on rise to achieve developmental targets. After the United States and Europe, China is the biggest consumer of fossil fuel where rapid increase in SO_2 and NO_xemissions is reported. South Asia is relatively safe from acid rain problems because of high buffering capacity of local dust in the atmosphere, which reacts with SO_2 and forms calcium sulfate. Ultimately, this results in higher pH of rain water. Similarly, acid rain is not an immediate problem in other parts of the world. However, consequences of increasing consumption of fossil fuel to meet energy demand in developing regions need to be monitored through national and international network programs. Apart from acidification of oceans by CO_2 rise, acid rain can also add to the process of acidification of coastal oceans, which might be damaging to the marine ecosystem in the future.

DOI: 10.1081/E-EEM-120047106, 1 May 2013.
http://www.tandfonline.com/doi/abs/10.1081/E-EEM-120047106#.VoNPKrZ95dg

Comparative study of indoor air pollution using traditional and improved cooking stoves in rural households of Northern India

Sudha Singh, Gyan Prakash Gupta, Bablu Kumar, UC Kulshrestha*

ABSTRACT

A major fraction of the rural population of India still burns biomass for domestic cooking and heating. Biomass materials such as wood, dung cakes and crop residues are burnt to produce energy for cooking. These are major sources of aerosol and gaseous pollutants in the atmosphere. Indoor measurements of gaseous species and chemical characteristics of aerosols contributed by burning biomass in traditional cooking stoves (TCS) vs. improved cooking stoves (ICS) are reported in this paper. Samples were collected from a village called Khairatpur, located in Sultanpur district of Uttar Pradesh state. The concentrations of aerosol components and gases in the indoor air during the operation of ICS were found to be lower as compared to TCS. On an average, total concentrations of major ions were lower by 32% during ICS operation. The most significant difference was observed for SO_4^{2-} aerosols (lower by 47%). Among SO_x, $NO_x$and NH_3 gases, SO_x showed maximum reduction (lower by 55%). Estimates of consumption of different types of biomasses showed that 621 t biomass is burnt annually by the villagers during cooking with TCS as compared to 365 t during ICS cooking. A social survey in the form of a questionnaire revealed that most of the women in the village of this study found ICS better than the TCS in terms of handling, reduced emissions, easier cooking and time & fuel efficiency.

Energy for Sustainable Development, Volume 19, April 2014, Pages 1–6
http://www.sciencedirect.com/science/article/pii/S0973082614000106

Airmass Trajectories and Long Range Transport of Pollutants: Review of Wet Deposition Scenario in South Asia

Umesh Kulshrestha and Bablu Kumar

ABSTRACT

This paper presents a review of airmass trajectories and their role in air pollution transport. It describes the concept, history, and basic calculation of air trajectories citing various trajectory models used worldwide. It highlights various areas of trajectory applications and errors associated with trajectory calculations. South Asian region receives airmasses from Europe, Middle East, Africa, and Indian Ocean, and so forth, depending upon the season. These airmasses are responsible for export and import of pollutants depositing in nearby states. Trajectory analysis revealed that soil is contributed by the dust storms coming from Oman through Gulf and Iran, while most of black carbon (BC) sources are located in India. A detailed review of trajectories associated with wet deposition events indicated that airmasses coming from Europe and Middle East carry high concentration of acidic pollutants which are deposited in Himalayan ranges. Similarly, trajectory analysis revealed that acidic pollutants from continental anthropogenic sources are transported to an ecosensitive site in Western Ghats in India and the outward fluxes of anthropogenic activities of Indo-Gangetic region are transported towards Bay of Bengal. Hence, transboundary and long range transport of pollutants are very important issues in South Asia which need immediate attention of scientists and policy makers.

Advances in Meteorology, Volume 2014 (2014), Article ID 596041, 14 pages
http://www.hindawi.com/journals/amete/2014/596041/abs/

Signatures of Increasing Energy Demand Of Past Two Decades As Captured In Rain Water Composition And Airmass Trajectory Analysis At Delhi (India)

Sudha Singh, Bablu Kumar, Gyan Prakash Gupta, U.C. Kulshrestha*

ABSTRACT

This study reports chemical characteristics of rain water in Delhi during monsoon (2010–11) with a comparison to earlier reported values of 1994. The results showed that non-marine sources had significant influence on rain water composition. The pH of the samples varied from 5.24 to 7.48 with an average value of 6.52 showing an alkaline nature of rain water. However, the dominance of NO3− over SO42− indicated higher influence of vehicular emissions over industrial sources at this urban site. Air mass trajectory analysis revealed that the easterly air masses were the most polluted which carried highest amount of NO3− and SO42−. The study highlighted that the difference in ion balance may be minimized by including measured HCO3− concentrations especially in Indian perspective where interference of soil-derived CaCO3 is reported very high. A comparison of this study with that of 1994 values reported earlier indicated a remarkable increase in the concentrations of various chemical components of rain water which might be due to the impact of industrial and urban expansion of the city since 1994. The maximum increase (~12 times) was noticed for NO3− concentrations, clearly reflecting the signatures of increased emissions of NOx from various anthropogenic sources, especially, vehicular emissions which are drastically increased during past two decades. In spite of introduction of CNG vehicles, Bharat stage I–IV emission norms and metro rail etc., increase of NOx suggests an immediate need of further stringent regulations.

Journal of Energy, Environment & Carbon Credits, Vol. 4, No. 3 (2014)
http://stmjournals.com/index.php?journal=JoEECC&page=article&op=view&path%5B%5D=5274

Deposition and Mineralogical Characteristics of Atmospheric Dust in relation to Land Use and Land Cover Change in Delhi (India)

Bablu Kumar, Kopal Verma, and Umesh Kulshrestha

ABSTRACT

This study highlights that the increasing urbanization and industrialization in Delhi are responsible for higher fluxes of atmospheric dust and its chemical constituents. Delhi has experienced a drastic change in land use and land cover area during the past two decades. Road lengths of the city have increased by 76% from 1985 to 2011. The number of mobile vehicles has reached 80,52,508 in 2014 from 24,32,295 in 1994. The industrial units in Delhi have increased by 39.54% in 2011 as compared to 1994 value. Atmospheric dust which is originated from soil in this region becomes carbon rich due to interaction of suspended soil with atmospheric pollutants. Emissions of carbonaceous aerosols from coal and petroleum combustions are mainly responsible for silica dominated soil dust transforming into carbon rich particulate matter. Such dust may play very important role in the atmosphere having significant influence on human health, global warming, climate change, radiative forcing, visibility, and cloud formation. It is expected that if the rate of development remains the same, green cover of the city invariably will be sized down in order to meet the demand of housing, transportation, industries, and so forth in proportion to the rising population.

Geography Journal, Volume 2014 (2014), Article ID 325612, 11 pages
http://www.hindawi.com/journals/geography/2014/325612/abs/

Rural versus urban gaseous inorganic reactive nitrogen in the Indo-Gangetic plains (IGP) of India

Saumya Singh, UC Kulshrestha

ABSTRACT

The present study reports on the abundance of reactive nitrogen (NH3 and NO2) at two sites, i.e. Okhla (urban site) in Delhi and Mai (rural site), located in the nearby state: Uttar Pradesh. The measurements were carried out during the period from October, 2012 to September, 2013 on a monthly basis. The average concentrations of NH3 at Okhla and Mai have been recorded as 40.4±16.8 and 51.57±22.8 μg m−3, respectively. The average concentrations of NO2 have been recorded as 24.4±13.5 and 18.8±12.6 μg m−3 at Okhla and Mai respectively.

Environmental Research Letters, 9, (2014) 125004 (9pp), DOI: 10.1088/1748-9326/9/12/125004
https://scholar.google.co.in/citations?view_op=view_citation&hl=en&user=7d3R8UEAAAAJ&cstart=40&citation_for_view=7d3R8UEAAAAJ:bFI3QPDXJZMC

Status of Atmospheric Mercury Research in South Asia: A Review

A. Kumari, B. Kumar, S. Manzoor, U.C. Kulshrestha

ABSTRACT

Mercury (Hg) is a highly toxic metal, which is known as a global pollutant due to its ability to undergo long-range transport in the atmosphere. Methylated mercury can pose serious adverse effects on human health and environment. Mercury is emitted into the atmosphere by various natural and anthropogenic sources. The largest anthropogenic source of mercury is coal combustion, which contributes ~62% of global emissions. Total global emissions of atmospheric mercury are estimated to be 5600 Mg/year from natural and anthropogenic sources, respectively, contributing around 37% and 63% of total atmospheric mercury. About 40% of global anthropogenic emissions are contributed by East and Southeast Asia with the largest emissions from China (75%) followed by South America and Sub-Saharan Africa. Latter regions are mainly responsible due to increase in artisanal and small scale gold mining. The present estimates of mercury emissions have large uncertainties in global budget, which are mainly due to lack of knowledge of mercury exchange between various components of ecosystem with its

speciation in spatial and temporal distribution. Special efforts are needed in the regions of growing economy especially in South Asia where atmospheric mercury is almost unattempted. In order to reduce uncertainties and get more realistic emission figures, there is need to develop an extensive monitoring network to measure various forms of mercury in air, soil and aquatic systems in south Asia. Controlling the emissions of global atmospheric mercury is a big challenge to the scientists and policymakers. Probably, it can be achieved by focusing on implementation of the available technologies and by developing new technologies for mercury removal through developing an extensive partnership between industries and governmental organizations.

Aerosol and Air Quality Research, Vol.15, No.3: 1092–1109, 2015
http://aaqr.org/VOL15_No3_June2015/31_AAQR-14-05-IR-0098_1092-1109.pdf

Long Range Transport and Wet Deposition Fluxes of Major Chemical Species in Snow at Gulmarg in North Western Himalayas (India)

B. Kumar, S. Singh, G.P. Gupta, F.A. Lone, U.C. Kulshrestha

ABSTRACT

The study reports snow chemistry and long range transport of pollutants at Gulmarg in north-western Himalayan region of India during winters of 2012–2013. The pH of snowmelt varied between 5.16 and 7.68 with an average of 5.90. The frequency distribution of pH of snowmelt showed that the maximum number of samples (31%) had pH between 6.81 and 7.20. However, 12% samples were observed to be acidic (below 5.6). Scavenging ratios (SR) values suggested that crustal components (Ca^{2+}, Mg^{2+}) are efficiently removed by snow. The study site has significant influence of non-marine sources. Wet deposition contributed 34, 27, 45, 71, 8 and 13 meq m^{-2} fluxes of $nssSO_4^{2-}$, NO_3^-, NH_4^+, $nssCa^{2+}$, $nssMg^{2+}$ and nss^{K+} respectively. Both local emissions as well as long range transport (LRT) of pollutants were found to be the sources of these ionic species. Backward airmass trajectory calculations showed that this site received airmasses from six major sectors i.e., i) North Atlantic Ocean origin (NAO), ii) African origin (Af), iii) Middle East origin (ME), iv) European origin (Eu), v) Western India origin (InW), vi) Pakistan origin (Pk). The highest average pH (7.58) of the snowfall was noticed during InW airmasses which had the lowest ratios of $nssSO_4^{2-}/nssCa^{2+}$ and $NO_3^-/nssCa^{2+}$. Very high pH has been observed in precipitation samples at Indian sites due to buffering of acidic components by atmospheric dust rich in $CaCO_3$. The lowest pH (4.94) was noticed for ME airmasses which had the highest $nssSO_4^{2-}/nssCa^{2+}$ and $NO_3^-/nssCa^{2+}$ ratios. Data of present study was compared with a study reported almost three decades ago. We noticed a drastic increase in the concentrations of anthropogenic components such as $nssSO_4^{2-}$ (114%), NO_3^- (109%) and NH_4^+ (90%). This is probably due to increase in LRT of pollutants as well as local activities during past three decades.

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http://aaqr.org/Doi.php?id=AAQR-15-01-SIMtS-0056_proof

Atmospheric Aerosols: Air Quality and Climate Change Perspectives

Shabana Manzoor and Umesh Kulshrestha

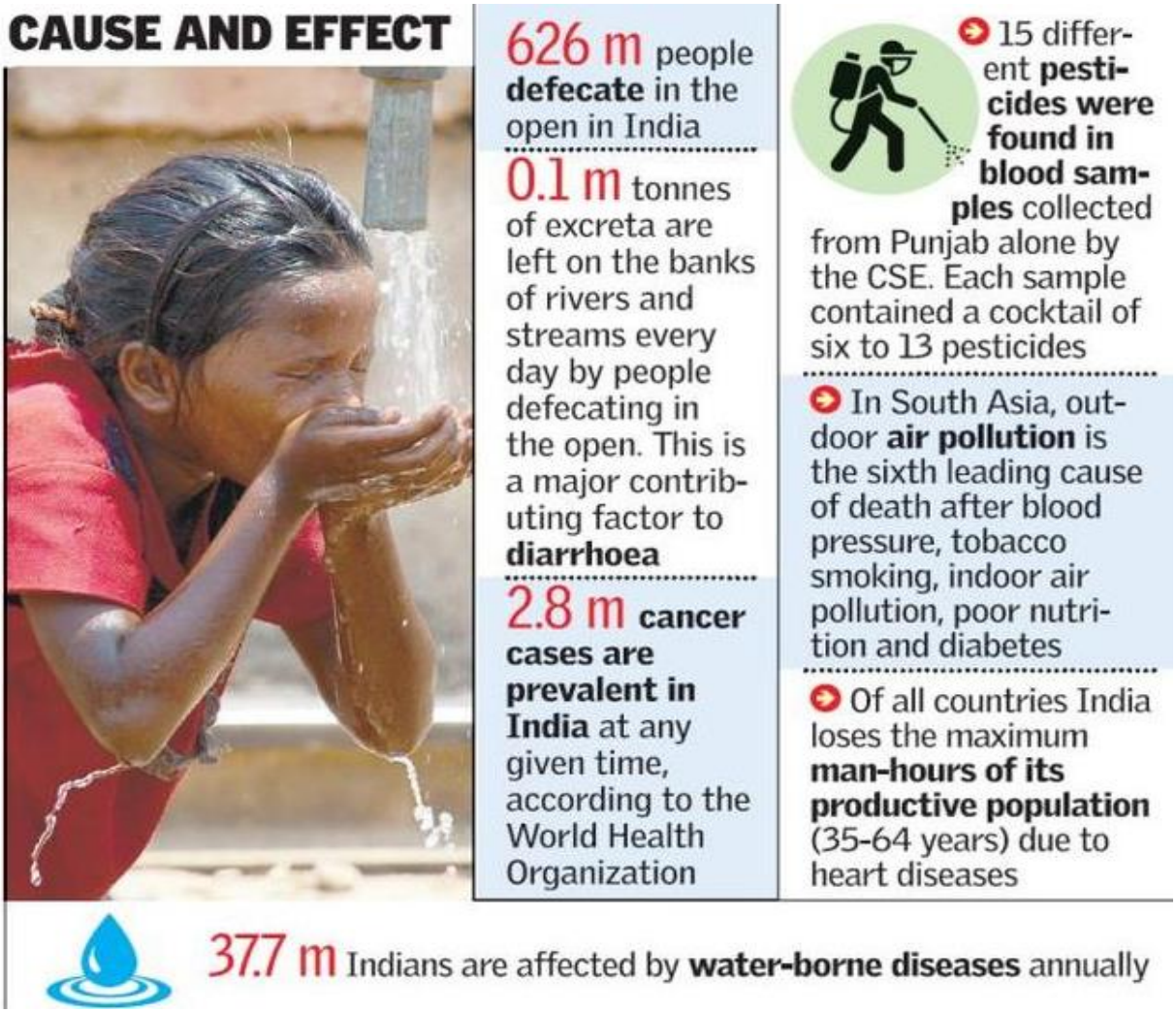
ABSTRACT

Recently, air quality has become a matter of concern of everyone. According to the reports, atmospheric aerosols play very crucial role in air quality. PM_{10} and $PM_{2.5}$ aerosols are integral parts of total su =spended particulate matter which affect our health. Often air quality has been reported very poor due to violation of National Ambient Air Quality Standard (NAAQS) limits. PM_{10} and $PM_{2.5}$ limits are crossed for both residential as well as sensitive sites. This is one of the major reasons of increasing cases of respiratory diseases in urban areas. However, aerosol loadings alone are not the factor for deciding or predicting toxic and harmful effects of aerosols. Chemical composition and size ranges do matter. Aerosol loadings can be due to three major source categories viz. marine, crustal and anthropogenic. Since, marine and crustal content of aerosols are generally non-toxic and hence, degree of toxicity of air needs to be decided on the basis of anthropogenic fraction having metals, PAHs and other harmful

content. Apart from air quality and health, atmospheric aerosols play vital role in other atmospheric processes such as cloud formation, radiative transfer and monsoon etc. Though there are several studies reported on different aspects of atmospheric aerosols, but most of the findings are sort of data reporting based on short term observations. Hence, there is need to investigate the atmospheric aerosols in order to demonstrate local and regional phenomenon on the basis of long term datasets.

Current World Environment, Vol. 10(3), 738-746 (2015)

http://www.cwejournal.org/vol10no3/atmospheric-aerosols-air-quality-and-climate-change-perspectives/



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Entitled: The assault on our bodies.