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Exceedance Level of Air Pollutants in an Urban Area as a Tool for Designing Air Purifiers

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Abstract:
The air pollution exceedance status of an urban area has been studied for three different location for six different air pollutants such as Sulphur dioxide (SO_2), Oxides of nitrogen (NOx), by Wet chemical method (West & Gaeke Method & Jacob & Hochheiser Method), Heavy Metal (Pb) by ICP-OES (Perkin Elmer), and PAHs [benzo(a)anthracene] & Fluoranthene by using GC (Perkin Elmer), and Particulate Matter (SPM, PM_{10},) by Federal Reference Method (Rupprecht & Patashnick Co.In) for one annual cyclic season along with meteorological data (wind speed and direction). Seasonally variation of air pollution parameters with respect to month throughout one year was studies and it has been observed that a suitable control over few pollutants is needed in all the land uses. The air purification system is hence evaluated for varying land uses. These results can be effectively used as tool for designing of air purification system.

Introduction:
Environmental contaminants are widely distributed in our environment. Therefore, they have an effect on the tropic food chain. Air, water and soil may contain many organic compounds and heavy metals of natural as well as anthropogenic origin.
Polycyclic aromatic hydrocarbons (PAHs) is a chemical compound that contain more than one fused benzene ring e.g Naphthalene, Anthracene, Phenanthrene, benz(a) pyrene, benz (a) anthracene, Fluoranthene, pyrene, benz(a)Fluoranthene etc. The point sources of anthropogenic origin are Coal gasification, heat and power generation, coke production, catalytic cracking, asphalt production and use, refining/distillation of crude oil, wood treatment and preservation, fuel operations, incineration and landfills/waste disposal which are stationary but air which is more divergent and affect not only stationary people but also a far distant of overall people in-outside city.

Nagpur City is the best place to study the interactions of atmospheric pollutants such as SO_2, NO_2 and suspended particulate matter (SPM) on vegetation, as it is high traffic zone with industrial area on the outskirts as well as have good vegetation cover in the city. Nagpur city is very well known as second Green City in India. Plantations are actively carried out every year in the city with the active participation of local administration and non-governmental organizations (NGOs). The city is also richly dotted by well-maintained parks, plantations, forest patches and agricultural fields. This has given lush green aesthetic appearance to the Nagpur city.
Present research is carried out, to study the status of urban pollution in relation to biodiversity in the Nagpur city using ambient air quality monitoring, remote sensing for land use cover, and biochemical responses of the trees to air pollution. Nagpur is a centrally located city in India wherein industrial and commercial growth is moderate. The source of

toxic air pollutants in Nagpur city is incomplete combustion of organic matter which is an important source of human exposure. Studies on various environmentally relevant matrices, such as coal, combusted effluent, motor vehicle expects, used motor fabricating oil and tobacco smoke have shown that the presence of PAHs in these mixtures is mainly responsible for the carcinogenic potential.

The city has a population of 46.53 lakhs according to the 2012census. There are industries setups as centers education and agriculture in Vidarbha region of Maharashtra State. The major air pollution sources are power plant and automobile exhausts. The city also experiences increasing floating population causing pressure on the civic services. The rate of population is directly proportional to pollution.

Effects of Pollutants on Living Things:

One of the adverse effects of the profuse use of fossil fuels by man now-a-days is presence of Polycyclic aromatic hydrocarbons (PAHs) and other toxic compounds in ambient dust in relatively high concentrations. They accumulate and thereby disrupt function in vital organs and glands such as the heart, brain, kidneys, bone, liver, etc. They displace the vital nutritional minerals from their original place, thereby, hindering their biological function.

Fig.-1: Population Growth in Nagpur City

This graph indicates that rise in population in Nagpur (Census 2011) is going on along with other normal activities like new construction sites for people residential, commercial, industrial, and thermal power production. Beside this there is also rise in industrial production capacity, no of vehicle, transportation in and outside city but relative pollution level is not rising as compared to that of others activities. These observations have been described in this paper with help of annual pollution level profile in graphical diagram for each air pollutant individually along with combined form.

Methodology:

SPM in ambient air was measured by using standard Hi-Vol sampling technique. RPM was measured by using respirable dust sampler designed and developed by the Institute. Gaseous samples were collected in absorbing solutions by taking tapping in Hi-Vol / RPM sampler at a point after passage of ambient air through glass fibre filter paper and the so collected samples were analysed using standard wet chemical techniques. The toxic trace metals and PAHs in RPM were analysed by precise, accurate and sensitive instrumental analytical techniques.

Heavy Metals : (Pb)

The Inductively Coupled Plasma-Optical Emission Spectrometers instrument is used for the detection of heavy metals form the extract of samples. The method is based on active sampling using PM_{10} High Volume Sampler and then sample analysis is done by Inductively Coupled Plasma-Optical Emission Spectrometers. One gram of dried and homogenized dust on filter paper was weighed into a beaker (100 ml) and 10 ml nitric acid was added. This was then heated until dryness. Thereafter, 10 ml HNO_3 and 3 ml $HClO_4$ was added and the solution was heated until fuming. The sample solution was obtained by processing the residue with hot 6 M HCl (4ml) and then filtered and diluted with water to 50ml.

Result & Discussion:

Overall several variations were observed among all the pollutants which have been analyzed for its correlations. Some of important result are being presented and discussed comparing and correlating with socialistic view of scientific observation via air pollution which is more divergent along with social, culture commercial and industrial scenario of human being in an urban area. These observations have been described in this paper with help of annual pollution level profile and exceedances in graphical diagram for each air pollutant individually along with combined form.

The **Fig.1** indicates that comparable diagram of SPM & PM_{10} for complete one year for Nagpur city for each site residential, commercial, industrial in different line in which green dots show SPM while red for PM_{10}.

In **Fig.2** a mean value of all sites has been presented separately for SPM and PM_{10} for one year for Nagpur city.

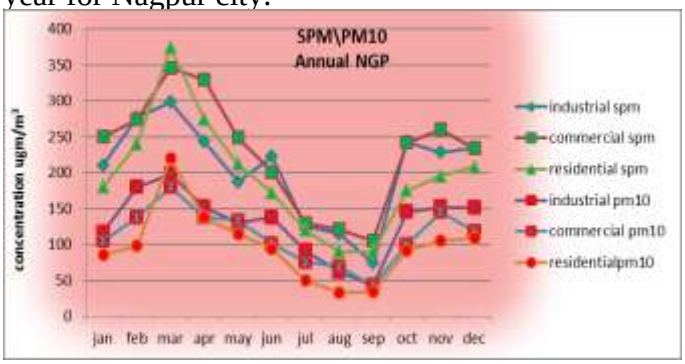

Fig.1 Comparable diagram of levels of SPM & PM_{10} for complete one year for Nagpur city

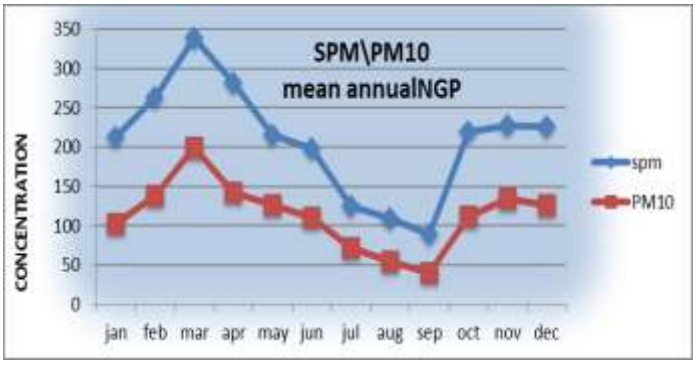

Fig.2 Comparable diagram of annual mean SPM & PM_{10} for complete one year for Nagpur city

There is an empirical relation between SPM and PM_{10} of which the variation profile is followed up in all month. During March their concentration gap is maximum but in Sept, it is minimum and PM_{10} value goes down below 50µg/m^3 and also SPM at 89.67 µg/m^3 may be due to post monsoon effect. Again their value rise up and continue up to march with maximum value as 199.93 µg/m^3 and 339.36 µg/m^3 respectively.

PM_{10} value oscillates from 50 – 200 µg/m^3 and SPM value from 89 – 339 µg/m^3. However this empirical relationship is only apparent because the whole sampling of PM have been performed 4 days per week and approx. 192 days in one year.

Similarly,

Fig.3 indicates that comparable diagram of SO_2, NO_2, NH_3, and H_2S gaseous pollutants for complete one year for Nagpur city for each site residential, commercial, and industrial in different line.

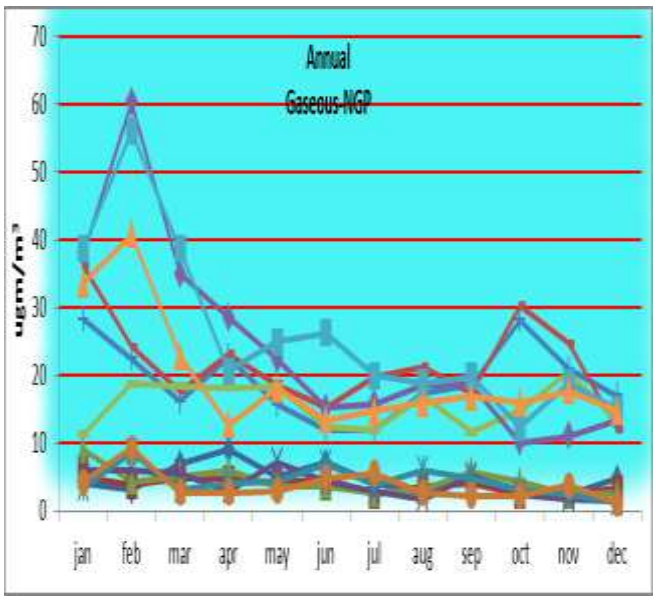

Fig.3 Comparable diagram of annual mean SPM & PM_{10} along with gases for complete one year for Nagpur city

Perusing the same pathway we have plotted all the above SO_2, NO_2, NH_3, and H_2S gaseous pollutants concentration including SPM,P10 and heavy metal (Pb) and Fluoranthene taking its mean of

residential, commercial, industrial value through whole year for the urban area. In somehow extant it seems to follow a regular path way variation profile from PM10 to all chemical including Organic Compound (PAHs). Their dependency and relationship of concentration of SPM with respect to other physical and chemical parameter air pollution empirically can be established in terms of all. All their concentration oscillates below and above STD limit of CPCB India.

Mathematically it is represented by a multiple linear regression equation.

$C_{spm\ mean\ annual}$ = - 23.968(±19.361)+$C_{PM10meanannual}$ X (1.627)(± 0.103)- $C_{Pb\ \ meanannual}$ X (53.097)(± 25.937)+ $C_{Fl\ mean\ annual}$ X (2732.517)(± 1504.355) - $C_{B(a)P}$ X (1305.736)(±690.01)-C_{SO2} x (5.601)(±3.240)-C NO_2 X(2.484)(± 0.944).

…eq. (1)

Where "C"= concentration in µg/m^3

Model Summary

R^2 = 0.996

Adjusted R Square=0.985

Std. Error of the Estimate=11.46

This relationship show that SPM is combined role of concentration of PM10, Pb,Fl,B(a)P,SO_2,NO_2. It means some of SPM is apparent composition of PM10, Pb,Fl,B(a)P,SO_2,NO_2. These material is always composed of chemical constitute. We are able to resolve it only 90-98% of total particulate matter because it is physical composite of every size of PM from0.01 upto 100 micro meter. We are planning for sampling to every size of PM separately so that we can categories different chemical composition of every PM size in different physical and chemical parameter profile to understand and explanation of complete PM scenarios.

Exceedance Factor of air Pollutants and impact on indoor air

It is an indicator which shows the fraction of the urban air population that is potentially exposed to ambient air (1) concentrations of pollutants (2) in excess of the regulatory (CPCB) limit value set for the protection of human health. The urban population considered is the total number of people living in cities with at least one monitoring station. If the factor exceeds 1 then the pollution levels are higher. Exceedances are observed for many pollutants most of the time during the year. These exceedances also pollute the indoor air which is normally an open system in most of the indoor built up areas of the city. Hence the boundary conditions for the design of air purifiers may to be set based on it. **Fig.4** shows the long term air pollution exceedance factor for various pollutants in an urban area

Air Purifier design inputs

Basic air filter specification begins with selecting filter dimensions to meet airflow and pollution control requirements and size constraints, then selecting a media configuration to meet performance and industry requirements. However, design improvements may be necessary to meet the challenges of the most demanding applications. Engineers and designers can further optimize filter design by relying on estimation of exceedances, ventilation requirements and other building/indoor volumes to be handled along with other custom applications. Hence estimation of exceedances may be used as tool for its designing.

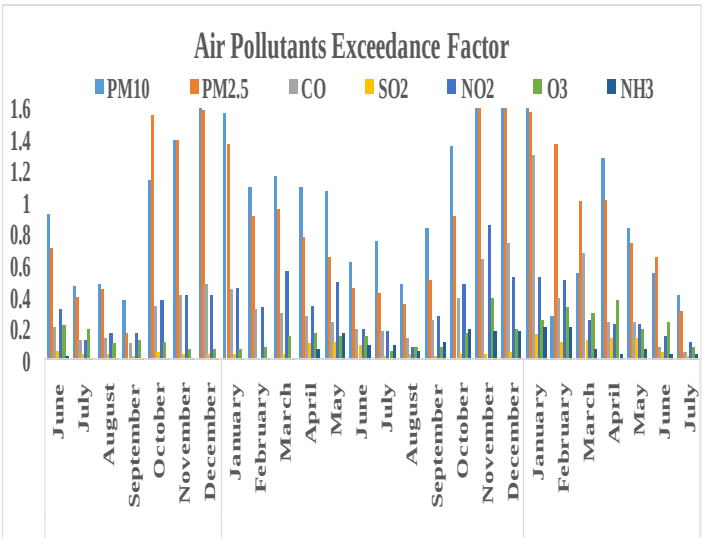

Fig.4 Long term exceedances of Air Pollutants in an Urban area

Fig.4 Long term air pollution exceedance factor of various pollutants in an urban area

References:

1. CPCB (2009, 2010, 2011) report on National Air Quality Status
2. I Natalya J Slet, W Petersell (2003), Effect of heavy metals and PAH on soil assessed via
3. dehydrogenase assay. Environmental International 28, 779 – 782.
4. M Alexander, (1985), Biodegradation of organic chemical. Environ. Sci. Techno. 18, 108 – 111.
5. M Kastner, S Streibich, M Beyrer, H H Richavid, W Fritsche, (1999).,Formation of bound residues during microbial. INT J MIRO, 65(5), 1834 – 1842.
6. M U Beg, T Saeed, S Al-Muzaini, K R Beg, and M Al – Bahloul,(2003),Distribution of
7. petroleum hydrocarbon in sediment from coastal area receiving industrial effluent in Kuwait.
8. Ecotoxicology and Environmental safety 54: 47 –52.
9. S S Wilson,, K C Jones, (1993),Bioremediation of soil contaminated with polynuclear aromatic hydrocarbons (PAHs) : A review . Environ. Pollut ; 81: 229 – 249.
10. A SC Lima, J.W. Farrington, and C.M. Reddy (2005), Combustion – derived polycyclic aromatic hydrocarbon in the environment- a review. Environ. Foren.
11. Boehm, P.D, Polycyclic aromatic hydrocarbons (PAHs). Chapter 15. In: Environmental Forensics, Contaminant specific Guide. R. Morrison and B.Murphy (eds.) Academic Press 1999.
12. P Boehm and T Saba (2008), Identification and Allocation of polycyclic aromatic hydrocarbons (PAHs). Environmental Forensic, Exponent vol. 4; 1 – 4.