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RESEARCH ARTICLE

Role of Air Samplers for Monitoring of Ambient Air Quality

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ABSTRACT

Air pollution is a major problem of our environment. Poor air quality of our environment is due to the increasing number of vehicles and a large number of established industries such as stone crusher industries, cement industries, steel industries and paper industries etc which cause a high concentration of suspended particulate matter, SO_x, NO_x, and CO_x etc. Concentration of these pollutants above their permissible limit in our environment causes harmful effect on human health as well as vegetation. Air born diseases such as asthma, silicosis, pneumoconiosis, chronic bronchitis, etc are caused by these air pollutants. So it is very important to monitor the quality of ambient air. Fine particulate sampler APM-550 as well as Gaseous pollutant sampler-433 play very important role for sampling of PM_{10}, $PM_{2.5}$, SO_x and NOx.

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INTRODUCTION

Air pollutants are added in the atmosphere from variety of sources that change the composition of atmosphere and affect the biotic environment. The concentration of air pollutants depend not only on the quantities that are emitted from air pollution sources but also on the ability of the atmosphere to either absorb or disperse these emissions. The air pollution concentration varies spatially and temporarily causing the air pollution pattern to change with different locations and time due to change in meteorological and topographical condition. The sources of air pollutants include vehicles, industries, domestic sources and natural sources. Because of the presence of high amount of air pollutants in the ambient air, the health of the population and property is getting adversely affected **(CPCB, 2009)**. Air pollution is one of the major causes of concern for deterioration of environmental conditions, particularly in developing countries. Air borne particles in the atmosphere have serious environmental impacts on climate **(Broecker, 2000; Prospero *et.al.*, 2000)** biogeochemical cycling in ecosystems **(Nriagu, 1988),** outside visibility and the health of living beings **(Dockery et.al., 1993)**. Suspended particulate matter, sulphur oxide (SO_x), nitrogen oxide (NO_x) and CO pollution cause a risk for human health **(Gupta and Gupta, 2014)** and exposure of these pollutants also affect vegetation growth due to adsorption of above pollutants on leaf, which prevented the process of respiration and photosynthesis **(Gupta *et.al.*, 2014)**.

Air Pollutants

Generally any substances biological, chemical or physical introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals or ecosystems is called air pollutants **(Bohra and Jinna, 2010)**. Air pollutants may be conveniently divided into two categories.

- Primary pollutants, such as sulpher dioxide, nitrogen oxide, particulates, nitrous oxide, Fog, Snaze and water vapour are emitted directly into the atmosphere.
- Secondary pollutants include tropospheric ground level ozone and peroxy acetyl nitrate, PAN **(Singh, B., 2006)**.

Suspended particulate matter

In general the term "particulate" refers to all atmospheric substances that are not gases. They can be suspended droplets of solid particles or mixtures of the two. Particulates can be composed of inert or extremely reactive materials ranging in size from 100µm down to 0.1 µm and less.

Oxides of sulphur (SO_x)

The most important oxide emitted by pollution sources is sulphur dioxide (SO_2). In a polluted atmosphere, SO_2 reacts photo chemically or catalytically with other pollutants or normal atmospheric constituents to form sulphur trioxide, sulphuric acid and salts of sulphuric acid. Sulphur oxides are the product of fossil fuel combustion, usually oil and coal **(Kiely, 2007)**.

Oxides of nitrogen (NO_x)

Out of the various oxides of nitrogen, only three oxides viz. nitrous oxide (N_2O), nitric oxide (NO), and nitrogen dioxide (NO_2) are formed in appreciable quantities in the atmosphere. Often NO and NO_2 are analyzed together in air and are referred to as NO_x .

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Oxides of carbon (CO_x)

Carbon forms two important gases with oxygen: carbon monoxide (CO) and carbon dioxide (CO_2). Carbon oxides are important components of the atmosphere, and they are parts of the carbon cycle. Carbon monoxide (CO) is toxic to humans and animals when encountered in higher concentrations, although it is also produced in normal animal metabolism in low quantities, and is thought to have some normal biological functions. In the atmosphere, Carbon dioxide (CO_2) is naturally produced by respiration and metabolism, and consumed by plants in their photosynthesis.

AIR POLLUTION PROBLEM IN INDIA

Air pollution in India is quite a serious issue with the major sources being fuelwood and biomass burning, fuel adulteration, vehicle emission and traffic congestion. In autumn and winter months, large scale crop residue burning in agriculture fields (a low cost alternative to mechanical tilling) is a major source of smoke, smog and particulate gases but the country as a whole is the third largest after china and United States.

Last year the WHO assessed 1,622 cities worldwide for $PM_{2.5}$ and found India home to 13 of the 20 cities with the most polluted air. More cities in India than in China see extremely high levels of such pollution. Especially to blame are low standards for the vehicle emissions and fuel. Nor, for different reasons, are rural people better off. Indoor pollution inhaled from dung-fuelled fires, and paraffin stoves and lights, may kill more than 1m Indians a year. The WHO says the vast majority of Indians breathe unsafe air. The human cost is seen in soaring asthma rates, including among children. $PM_{2.5}$ contributes to cancer and it kill by triggering heart attacks and strokes. Air pollution is likely to cause vastly more deaths as Indians grow older and more obese. Indoor and outdoor pollution combined is the biggest cause of death, claiming over 1.6m lives a year (Gupta, 2015).

Delhi, the sixth-most populated metropolis in the world, is one of the most heavily polluted cities in India, having for instance one of the country's highest volumes of particulate matter pollution. In May 2014 the World Health Organisation announced New Dehli as the most polluted city in the world. Overpopulation and the ensuing overuse of scarce resources such as water put heavy pressure on the environment. The city suffers from air pollution caused by road dust and industry, with comparatively smaller contributions from unclean engines in transportation, especially diesel-powered city buses and trucks, and 2-wheelers and 3-wheelers with two-stroke engines. Delhi has been lost the competition to host the 2014 Asian Games because of its poor environment (http://en.m.wikipedia.org/wiki/nvironmental_issues_in_Delhi).

Air pollution in India is mainly caused from three sources namely vehicles, industrial and domestic sources. The air pollution is mainly concentrated in following three areas:

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(i) Major Cities: The problem of air pollution is in major cities where the prominent source of air pollution is vehicles and small/medium scale industries. These cities include Delhi, Kolkata, Mumbai, Chennai, Ahmedabad, Bangalore, Hyderabad, Pune, Kanpur etc.

(ii) Critically Polluted Areas: 24 critically polluted areas have been identified in India where the problem of pollution exists. These areas are as follows:

Table 1.1: Problem Areas in India

S. No	Problem area	Type of Industry
1	Singrauli	Power Plants, Mining, Aluminium Industry
2	Korba	Power Plants,Aluminium Industry, Mining
3	Vapi	Chemical Industries
4	Ankaleshwar	Chemical Industries
5	Greater Cochin	Oil Refineries, Chemical, Metallurgical Industries
6	Visakhapatnam	Oil Refinery, Chemical, Steel Plant
7	Howrah	Foundry, Rerolling Mills
8	Durgapur	Chemical Industries, Power Plants, Steel Plants.
9	Manali	Oil Refineries, Chemical Industry, Fertilizer Industry
10	Chembur	Refineries, Power Plant, Fertilizer Industry
11	Mandi Gobindgarh	Secondary Steel Industry
12	Dhanbad	Mining, Coke Oven
13	Pali	Cotton Textile, Dyeing
14	Nagafgarh Drain Basin	Power Plants, Vehicles
15	Angul-Talcher	Mining, Aluminium Plants, Thermal Power Plants
16	Bhadravati	Iron & Steel, Paper Industry
17	Digboi	Oil Refinery
18	Jodhpur	Cotton Textile, Dye
19	Kala-Amb	Paper, Electroplating
20	Nagda-Ratlam	Viscose Rayon, Caustic, Dyes, Distillery
21	North Arcot	Tanneries
22	Parwanoo	Food Processing Unit, Electroplating
23	Patancheru - Bollaram	Organic Chemical, Paints Petrochemical Industry
24	Tarapur	Chemical Industry

(iii) Rural Areas: The indoor air pollution exists in rural areas where the main source of air pollution is domestic fuel used. In rural areas cow dung, wood sticks are used as fuel in household. The kitchens are without any proper ventilation resulting in buildup of air pollutants in the houses.

Reasons for High Air Pollution in India

The reasons for high air pollution in India are as follows:

(i) Poor Quality of Fuel

Fuel of poor quality such as coal, diesel, petrol, fuel oil is used in India. Although during the past few years, various measures have been taken to improve

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the quality of fuel such as reduction of sulphur in diesel, unleaded petrol etc.

(ii) Old Process Technology
Old process technology is employed in many industries especially in small scale industries resulting in high emission of air pollutants

(iii) Wrong Siting of Industries
Wrong siting of industries especially close to residential areas results in people getting affected due to air pollution.

(iv) No Pollution Preventive Step in Early Stage of Industrialization
No pollution preventive steps were taken in early stage of industrialization which has resulted in high levels of air pollutants in many areas.

(v) Poor Vehicle Design
Poor vehicle design especially 2-stroke two wheelers result in high emission of air pollutants.

(vi) Uncontrolled Growth of Vehicle Population
Uncontrolled growth of vehicle population in all major cities/towns has resulted in high levels of air pollution.

(vii) No Pollution Prevention and Control System in Small/ Medium Scale Industry
No pollution prevention and control system in small/medium scale industry exists resulting in high levels of air pollution.

(viii) Poor Compliance of Standard in Small/Medium Scale Industries
Poor compliance of standard in small/medium scale industries also result in high levels of air pollution.

MATERIALS AND METHOD

Monitoring of fine particulate matter and gaseous pollutants can be done with the help of instruments named as fine particulate matter APM 550 and gaseous pollutants APM 433 respectively. Central Pollution Control Board (CPCB) test methods were followed for measuring particulate matter and analyzing gases. Gravimetric method is used for measuring PM_{10} and $PM_{2.5}$ while gaseous pollutants, SO_2 and NO_x in ambient air can be measured with the help of wet chemical method. Modified West- Gaeke method was applied for SO_2 and NO_x was determined by Sodium Arsenite method. These methods are fairly simple and can be employed, easily in India.

Measurement of Respirable Suspended Particulate Matter (PM_{10} and $PM_{2.5}$)

(a) Principle

An electrically powered air sampler drew ambient air at constant volumetric flow rate (16.7 lpm) maintained by a mass flow / volumetric flow controller coupled to a microprocessor by a mass flow / volumetric flow controller coupled to a microprocessor into specially designed intertial particle- size separator (i.e. cyclones or impactors) where the suspended particular matter in the $PM_{2.5}$ size ranges is separated for collection on 47 mm polytetrafluoroethylene (PTFE) filter over a specified sampling period. Each filter is weighted before and after sample collection to determine net gain due to the particulate matter. The mass concentration in the ambient air is computed as total mass of collected

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particle in the $PM_{2.5}$ size ranges divided by the actual volume of air sampled and is expressed in $\mu g/m^3$. The microprocessor read averages and stored five-minute averages of ambient temperature, ambient pressure, filter temperature and volumetric flow rate.

(b) Apparatus

The APM 550 system is a manual method for sampling fine particles ($PM_{2.5}$ fraction) and is based on impactor designs standardized by USEPA for ambient air quality monitoring. Ambient air enters the APM 550 series samplers system through an omni-directional inlet designed to provide a clean aerodynamic cut-point for particles greater than 10 microns. Particles in the air stream finer than 10 microns proceed to a second impactor that has an aerodynamic cut-point at 2.5 microns. The air sample and fine particulates exiting from the $PM_{2.5}$ impactor are passed through a 47 mm diameter Teflon filter membrane that retains the fine particulate matter. The sampling rate of the system is held constant at 1 m^3/hr by a suitable critical orifice. The standard system is supplied with a Dry Gas Meter to provide a direct measure of the total air volume sampled.

Filter media –

47 mm Filter: 47 mm (diameter) teflon (PTFE) filter paper with PP (polypropylene) support ring with 46.2 mm effective diameter having 2µm pore sizes manufactured by Whatman was used.

37 mm Filter: 37 mm diameter glass microfiber filters paper (GF/A) manufactured by Whatman was used.

(c) **Calculation of PM_{10} or $PM_{2.5}$ in ambient air**

$PM_{10}/PM_{2.5} = (W_f - W_i) \times 10^6/V$

where PM_{10} or $PM_{2.5}$= Mass concentration of particulate matter less than 10 or 2.5 micron diameter in $\mu g/m^3$, W_i = Initial weight of filter in gm, W_f = Final weight of filter in gm, 10^6= conversion of gm to µg, V = Volume of air sampled in m^3

Measurement of Gaseous pollutants (SO_x and NO_x)

Principle

For determination of concentration of gaseous pollutant in air, it is necessary to obtain representative samples of air at a number of strategic points. The concentrations are likely to vary with time and distance from the source of pollution depending upon the nature of release, meteorological factors and local conditions such as topography and presence of buildings and vegetation. The measured concentrations are also known to depend upon the average time namely, the period of sampling. These aspects are required to be taken into account for sampling and interpretation of the measured values.

Apparatus

Gaseous Pollutants Sampler APM 433 is a complete system used for sampling of SO_x and NO_x. Units is supplied with a suction pump to obtain desirable sampling flow rate required for specific pollutant provision for thermo electric cooling around impingers has been incorporated in this instrument thus no ice need to be kept around impingers.

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Further temperature control and display has been incorporated for effective control on cooling. At the outlet of each impingers drying tubes have been fitted which ensures that fine particulates and moisture escaping from impingers (after bubbling of air in the absorbing media) do not reach to needle valve of manifold. Thus measurement is existing and an offline rotameter has been fitted in the instrument suitable for setting of flow in impingers. Individual needle valve of manifold can be used with the help of screw driver.

RESULTS AND DISCUSSION

Under the Air (Prevention and Control of Pollution) Act, 1981, the Central Pollution Control Board (CPCB) initiated National Ambient Air Quality Monitoring programme in the year 1984 and the network of monitoring stations has been extended throughout the country. The results of ambient air quality monitoring should be compared with the prescribed values of National Ambient Air Quality Standards (NAAQS) recommended by Central Pollution Control Board (CPCB). The ambient air quality standard with respect to pollutants by Central Pollution Control Board and World Health Organization (WHO) is presented in table 1.2 and table 1.3 respectively. Ambient air quality monitoring programme are needed to determine the existing quality of air in our environment, evaluation of the effectiveness of control programme and to develop new programme.

Table-1.2 National ambient air quality standards, CPCB (2009)

Pollutants	Time weighted average	Concentration in ambient air		Methods of measurement
		Industrial, residential, rural and other areas	Ecologically sensitive area (Notified by Central Government)	
Sulphur Dioxide (SO_2), µg/m^3	Annual* 24 Hours**	50 80	20 80	Improved West and Gaeke Method
Nitrogen Dioxide (NO_2), µg/m^3	Annual* 24 Hours**	40 80	30 80	Jacob and Hochheiser modified (NaOH and $NaAsO_2$) Method
Particulate Matter (Size less than 10 µm) or PM_{10}, µg/m^3	Annual* 24 Hours**	60 100	60 100	Gravimetric Method
Particulate Matter (Size less than 2.5 µm) or $PM_{2.5}$, µg/m^3	Annual* 24 Hours**	40 60	40 60	Gravimetric Method
Carbon Monoxide (CO), mg/m^3	8 Hours ** 1 Hours**	02 04	02 04	Non- dispersive Infrared (NDIR) Method

* Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values as applicable.

When concentrations of these pollutants are above the permissible limit in ambient air of our environment, cause various serious health problems.

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Table-1.3 Ambient air quality standard, WHO (2005)

Pollutants	Time weighted average	Concentration in ambient air
Sulphur Dioxide (SO_2), $\mu g/m^3$	24 hour mean	**20**
Nitrogen Dioxide (NO_2), $\mu g/m^3$	24 hour mean	**25**
Particulate Matter (Size less than 10 µm) or PM_{10}, $\mu g/m^3$	24 hour mean	**50**
Particulate Matter (Size less than 2.5 µm) or $PM_{2.5}$, $\mu g/m^3$	24 hour mean	**25**

CONCLUSION

Air pollution is characterized by diverse effects on human health, the ecosystem, climate and materials. Interestingly the important role of air pollutants in genesis and augmentation of allergic disorder which can lead to enhance risk of infection and diseases by causing immune supersession has been reported. The long range transport of this particulate matter within countries and between countries has raised awareness of research that is aimed at reducing their effects in the last 2 decades. The estimates of economic costs of particulate matter pollution on human health and material degradation will help in the accurate assessment of economic damages resulting from particulate matter. Various control measures that could minimize the effects of the particulate matter and gaseous pollutants have been identified. A well-coordinated approach is needed, which should involve all-the public, the NGOs, the government agencies, the private sector; to tackle the menace of air pollution. Lest it b
ecomes uncontrollable.

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