Punjab ENVIS Centre

NEWSLETTER

Vol. 11, No. 1, 2013-14

AIR QUALITY : STATUS & TRENDS IN PUNJAB

Environmental Information System
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PSCST
PUNJAB STATE COUNCIL FOR SCIENCE & TECHNOLOGY

Status of Environment & Related Issues

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EDITORIAL

Over the past half-century, scientists have learned much more about the causes and impacts of atmospheric pollution. Many nations have greatly reduced their emissions, but the problem is far from solved. In addition to threatening human health, air pollutants damage ecosystems, weaken Earth's stratospheric ozone shield, and contribute to global climate change. The World Health Organization (WHO) estimates that about two million people die prematurely every year as a result of air pollution, while many more suffer from breathing ailments, heart disease, lung infections and even cancer. Air pollution in India has increased rapidly because of intensive population growth, increase in the numbers of vehicles, use of fuels with poor environmental performance, badly mentioned transportation systems, poor land use pattern, industrialization, and above all, ineffective environmental regulations (Chattopadhyay *et al.*, 2010). In most of the 23 Indian cities with a million-plus population, air pollution levels exceed World Health Organization's (WHO) recommended health standards. In every city, the levels are getting worse because of rapid industrialization, growing number of vehicles, energy consumption, and burning of wastes.

Present article in this newsletter throws light on the issue of Air Quality in Punjab, status and trends. Briefly discusses possible reasons governing air quality of Punjab. Further it touches upon some of the mitigation steps which can be adopted to improve air quality of the state.

EDITORS

ENVIS Centre, PSCST is a partner of Regional Centre of Expertise (RCE) Chandigarh. RCE Network is an initiative of United Nations University – Institute of Advanced Studies, Japan, which focuses on Education for Sustainable Development (ESD). This article on Air Quality of Punjab reinstate PSCST's endeavor to create awareness for sustainable growth.

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Published by

Punjab ENVIS Centre
Punjab State Council for Science & Technology, Chandigarh

Sponsored by

Ministry of Environment & Forest, Government of India

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To obtain information from grass root level for further dissemination, the Centre invites articles, review papers, case studies or news items relevant to the subject area for publishing the same in the forthcoming issues of the Newsletter.

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INTRODUCTION

Earth's atmosphere is a complex self-regulating system that provides a protective envelope in which life thrives. It consists of dynamic natural gaseous system (consisting of mainly nitrogen, oxygen, argon, water vapor, and a number of trace gases) which is essential to support life on planet earth. The composition of these gases has remained relatively constant throughout much of Earth's history. Many chemical reactions maintain the ratios of major constituents of the atmosphere to each other. However, there are four major types of processes that affect air quality:

1. **Emissions:** Chemicals are emitted to the atmosphere by a range of sources; anthropogenic emissions come from human activities, such as burning of fossil fuel, biogenic emissions are produced by natural functions of biological organisms, such as microbial breakdown of organic materials, emissions can also come from natural sources, volcanic eruptions and desert dust.
2. **Chemical reactions:** Many types of chemical reactions in the atmosphere modify, and destroy air quality.
3. **Transportation:** Winds can carry pollutants far from their sources, leading to environmental impacts in far away areas.
4. **Deposition:** Materials in the atmosphere returns to Earth, either because they are directly absorbed or taken up in a chemical reaction (such as photosynthesis) or because they are scavenged from the atmosphere and carried to Earth by rain, snow, or fog.

Thus, the quality of air depends on key chemicals emitted in the atmosphere during the above stated processes. Air quality is a measure of the condition of air relative to the requirements of one or more biotic species or to any human need or purpose. Various contaminants continuously enter the atmosphere through natural and man-made processes and these contaminants interact with the environment to cause disease, toxicity, environmental decay *etc.* and are labeled as pollutant. Air Pollutants means any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment. Some of the major pollutants are summarized in Box 1.

Box 1. Major air pollutants

Nitrogen oxide (NOx) causes smog and acid rain. It is produced from burning fuels including petrol, diesel, and coal. Nitrogen oxides can make children susceptible to respiratory diseases in winters.

Suspended particulate matter (SPM) consists of solids in the air in the form of smoke, dust, and vapour that can remain suspended for extended periods and is also the main source of haze which reduces visibility. When breathed in, SPM can lodge in our lungs and cause lung damage and respiratory problems.

Sulphur dioxide (SO_2) is a gas produced from burning of coal, mainly in thermal power plants. Some industrial processes, such as production of paper and smelting of metals, produce sulphur dioxide. It is a major contributor to smog and acid rain. SO_2 can lead to lung diseases.

Carbon monoxide (CO) is a colorless and odorless gas that is produced by the incomplete burning of carbon-based fuels including petrol, diesel & wood and produced from the combustion of natural & synthetic products such as cigarettes. It lowers the amount of oxygen that enters our blood. It can slow our reflexes and make us confused and sleepy.

Carbon dioxide (CO_2) is the principle greenhouse gas emitted as a result of human activities such as the burning of coal, oil and natural gases.

Chloroflorocarbons (CFC) are gases that are released mainly from air-conditioning systems and refrigeration. When released into the air, CFCs rise to the stratosphere, where they come in contact with few other gases, which lead to a reduction of the ozone layer that protects the earth from the harmful ultraviolet rays of the sun.

Lead is present in petrol, diesel, lead batteries, paints, hair dye products, etc. Lead affects children in particular. It can cause nervous system damage and digestive problems and, in some cases, cause cancer.

Ozone (O_3) occurs naturally in the upper layers of the atmosphere & shields the earth from the harmful ultraviolet rays of the sun at the ground level, it is a pollutant with highly toxic effects. Vehicles & industries are the major source of ground-level ozone emissions. Ozone makes our eyes itch, burn, and water. It lowers our resistance to colds and pneumonia.

Source: http://edugreen.teri.res.in

Worldwide, the most widely monitored air pollutants are primary air pollutants (emitted directly into the air from sources) and secondary air pollutants (chemicals formed through reactions in the atmosphere).

Particulate Matter, Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_x), Carbon monoxide (CO), Lead (Pb) and Ozone (O_3) are also called Criteria Pollutants, as they are the most common indicators of air quality. The secondary pollutants are formed when primary pollutants react in the atmosphere during various reactions like bimolecular (two reactants combine to produce two products), three-body (two reactants combine to form one new product. A third, inert molecule stabilizes the end product and removes excess energy), Photolysis (Solar radiation photon breaks a chemical bond in a molecule), Thermal decomposition (A molecule decomposes by collision with an inert molecule), etc.

Thus, air pollutants pass through many complex reactions in the atmosphere and their residence times vary widely, so it not always straightforward to estimate how emission reductions from specific sources will impact air quality over time. Major air pollutants classified on the basis of their sources are given in Box 2.

Everywhere in the world, modernization and changing lifestyle has led to air getting more and more polluted over the years. Industries, vehicles, increasing population, and urbanization are some of the major factors responsible for deteriorating quality of air. The following industries are among those that emit a great deal of pollutants into the air: cement, steel, refineries, petro chemicals, thermal power plants and mines. Pollutants emitted from such sources are responsible for thinning of the protective ozone layer of the atmosphere.

In India, during the past four decades air quality has been aggravated by developments that are typically occurring as our states becoming more industrialized with growing cities, increasing traffic, rapid economic development, higher levels of energy consumption. This change is leading to high influx of population to more industrialized cities. Centre for Science and Environment (CSE) analysis of government data and the WHO's *Global Burden of Disease* report's data on India has shown that poor air quality is the fifth leading cause of death in India after high blood pressure, indoor air pollution, tobacco smoking and poor nutrition, with about 620,000 premature deaths occurring from air pollution-related diseases. India faces an unprecedented public health crisis due to air pollution *(February 14, The Economic Times, 2013).*

Box 2. Major air pollutants from different sources

Source of Emission	Major Pollutants
Industries	Particulate matter, oxides of carbon, nitrogen and sulphur, ozone, toxic chemicals, etc.
Vehicular exhaust	Particulate matter, carbon monoxide, hydrocarbons, oxides of nitrogen, lead etc
Domestic Sources	Suspended particulate matter, carbon dioxide, NO_x, So_2
Development Works	Particulate matter, dust
Agricultural waste burning	Suspended particulate matter, oxides of carbon, dust

Source: http://edugreen.teri.res.in

In order to arrest the deterioration of air quality and address the environmental concerns, the Govt. of India has enacted Air (Prevention & Control of Pollution) Act in 1981and Environment (Protection) Act, 1986. It is therefore, necessary to assess the present and anticipated air pollution through continuous air quality survey/monitoring programs. During monitoring the concentration of different air pollutants within study area are evaluated which are further used to calculate Air Quality Index (AQI) as explained in Box 3.

Box 3. Air quality index

Air Quality Index (AQI) is one of the important tools available for analyzing and representing air quality status uniformly, it's used as a measure to assess the relative change in the concentrations of groups of pollutants in two situations which may represent either two time periods or two regions. The relative change may also be with respect to the concentrations of pollutants and respective stipulated standards (Chelani *et al.,* 2002).

With the intent that ambient air quality information must reach common people in a easily understandable terms, Central Pollution Control Board (CPCB) has developed an Air Quality Index (AQI) in collaboration with Indian Institute of Technology (IIT), Kanpur for easy calculation of Air Quality of a particular place/in a day/month/year for simpler way for the public and others. The index has been developed based on the dose-response relationship of various pollutants.

The index is named as IND-AQI (Indian Air Quality Index). A minimum number of three pollutant parameters (RSPM, SO_2 and NO_2) are essential to calculate the INDAQI. Any additional information on other pollutants such as PM 10, PM 2.5, CO and O_3 are included to calculate conclusive and complete value of index.

Source: www.iitk.ac.in

NATIONAL AIR QUALITY MONITORING PROGRAMME (NAMP)

The Central Pollution Control Board had started National Ambient Air Quality Monitoring (NAAQM) Network during 1984 - 85 at national level. The programme was later renamed as National Air Quality Monitoring Programme (NAMP). The air quality monitoring network has been strengthened by increasing the number of monitoring stations from 28 in 1985 to 456 operating stations spread over 190 cities/town and industrial area in 26 states and 5 union territories as on march 31st 2011 (CPCB, 2011) .

Under NAMP, three air pollutants viz., Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), and Particulate Matter having size less than or equal to 10 micron (PM10), have been identified for regular monitoring at all the locations. The monitoring of meteorological parameters such as wind speed, wind direction, relative humidity and temperature was also integrated with the monitoring of air quality at selected locations. In all the NAMP stations, monitoring of pollutants is carried out for 24 hours (4-hourly sampling for gaseous pollutants and 8-hourly sampling for particulate matter) with twice a week frequency to have at least 104 observations in a year.

The objectives of the NAMP are as follows:

- To determine status and trends of ambient air quality;
- To ascertain whether the prescribed ambient air quality standards are violated;
- To Identify non-attainment Cities where air pollutants are exceeded prescribed standards;
- To obtain the knowledge and understanding necessary for developing preventive and corrective measures;
- To understand the natural cleansing process undergoing in the environment through pollution dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated.

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

The ambient air quality standards are pre-requisite for developing management programme for effective management of ambient air quality and to reduce the damaging effects of air pollution. The objectives of air quality standards are: -

- To indicate the levels of air quality necessary with an adequate margin of safety to protect the public health, vegetation and property.
- To assist in establishing priorities for abatement and control of pollutant level.
- To provide uniform yardstick for assessing air quality at national level.

CPCB adopted the National Ambient Air Quality Standards (NAAQS) on November 11, 1982 as per section 16 (2) (h) of the Air (Prevention and Control of Pollution) Act, 1981. The air quality standards have been revised by the CPCB on April 11, 1994 and were notified in Gazette of India, Extra-ordinary Part-II Section 3, sub section (ii), dated May 20, 1994. Further in 2009, NAAQS have been revisited in consultation with civil society and experts for 12 pollutants which include SO_2, NO_2, PM10, PM2.5, Ozone, Lead, Arsenic, Nickel, CO, NH_3, Benzene, and B(a)P (particulate phase). The revised National Ambient Air Quality Standards (NAAQS) are shown in Table-1. These standards are based on the land use and other factors of the area.

MoEF/CPCB further gave guidelines (Box 4) for declaring Ecologically Sensitive Areas (ESA) on the basis of recommendation of peer/core group of CPCB.

FACTORS AFFECTING AIR QUALITY OF PUNJAB

Punjab is predominantly an agrarian state and in last few decades there has been tremendous growth in industrial sector. Agriculture based economy of the state provided financial prosperity to its people; hence an increase in number of motor vehicles in the state. This growth has contributed to air pollution which is widespread in urban areas where vehicles are the major contributor. Some cities and towns of the state have pollution due to high concentration of industries, agricultural sources, etc. The major factors effecting air quality of Punjab are briefly discussed in the succeeding text.

1) Vehicular growth

The rapid increase in urban population has resulted in unplanned urban development, increase in consumption patterns and higher demands for transport, energy and other infrastructure thereby leading to various pollution problems. Vehicular emissions are of particular concern since these are ground level sources and thus have the maximum impact on the general human population and other biotic component. Automotive vehicles emit several pollutants depending upon the type of quality of the fuel consumed by them.

Box 4. Ecologically sensitive areas

Ecological Sensitive Areas may include the following:

1. 10 km all around the periphery of health resorts so notified by State Pollution Control Boards in consultation with department of public health of the concerned state.
2. 10 km all around the periphery of biosphere reserves, sancturies and national parks, so notified by Ministry of Environment and Forest or concerned states.
3. 5kms all around the periphery of an archaeological monument declared to be of national importance or otherwise so notified by Archaeological Survey of India (ASI) in consultation with State Pollution Control Boards.
4. Areas where some delicate or sensitive to air pollution crops/important to the agriculture/horticulture of that area are grown so notified by State Pollution Control Boards in consultation with department of agriculture/horticulture of concerned state.
5. 5 km around the periphery of centres of tourism and/or pilgrim due to their religious, historical, scenic or other attractions, so notified by department of tourism of the concerned state with State Pollution Control Boards.

Source: Central Pollution Control Board

Table 1. National ambient air quality standard (NAAQS)

Pollutant	Time Weighted Average	Concentration in Ambient Air		
		Industrial Residential, Rural and Other Area	Ecologically Sensitive Area (notified by Central Govt.)	Method of Measurements
Sulphur Dioxide (SO_2) ug/m^3	Annual*	50	20	- Improved West and Goeke
	24 hours**	80	80	- Ultraviolet flourescence
Nitrogen Dioxide (NO_2) ug/m^3	Annual*	40	30	- Modified Jacob & Hochheiser(Na-Arsenite) Chemiluminescence
	24 hours**	80	80	
Particulate Matter (size less than 10 um) or PM10ug/m^3	Annual*	60	60	- Gravimetric
	24 hours**	100	100	- TOEM - Beta attenuation
Particulate Matter (size less than 2.5 ug) or PM2.5ug/m^3	Annual*	40	40	- Gravimetric
	24 hours**	40	60	- TOEM - Beta attenuation
Ozone (O_3) ug/m^3	Annual*	100	100	- UV Photometric
	24 hours**	180	180	- Chemiluminescence - Chemical Method
Lead (Pb)	Annual*	0.50	0.50	- AAS/ICP method after sampling on EPM 2000 or equilvalent filter paper - ED-XRF using Teflon filter
	24 hours**	1.00	1.00	
Carbon Monoxide (CO) ug/m^3	Annual*	02	02	- Non Disoerive Innfrared Spectroscopy
	24 hours**	04	04	
Ammonia (Nh_3) ug/m3 method	Annual*	100	100	- Chemiluminescence
	24 hours**	400	400	- Indophenol blue
Benzene (C_4H_4) ug/m^3	Annual*	05	05	- Gas Chromatography based continuous analyer - Adsorption and Desorption followed by GC analysis
Benzo Pyrene (BaP)-particulate phase only ng/m^3	Annual*	01	01	- Solvent extraction followed by HPCL/GC analysis
Arsenic (As) ng/m^3	Annual*	06	06	- AAS/ICP method after sampling on EPM 2000 or equivalent filter paper
Nicke (Ni) ng/m^3	Annual*	20	20	- AAS/ICP method after sampling on EPM 2000 or equivalent filter paper

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

** 24 hourly or 08 hourly or 01 hourly monitored values as application shall be compiled with 98% of the time in a year, 2% of the time they exceed the limits but not on two consecutive days of monitoring.

NOTE: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

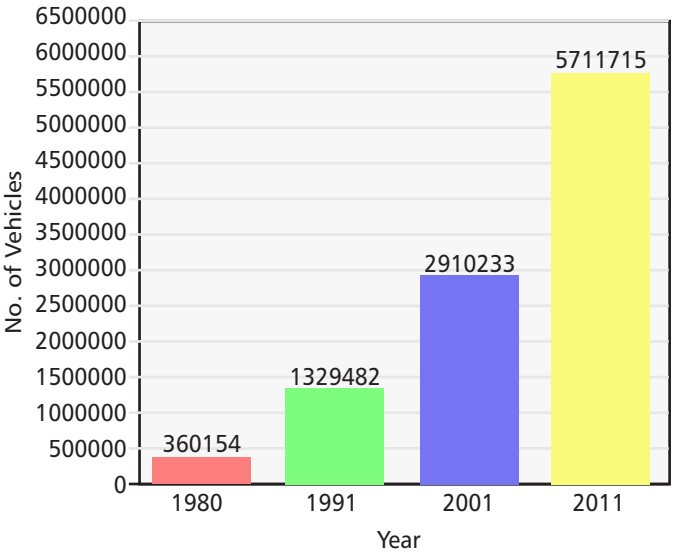
Source: MoEF, GoI, 2009

Rapid Growth in Motor Vehicles

The major pollutants released as vehicle/fuel emissions are, carbon monoxide, nitrogen oxides, photochemical oxidants, air toxics namely benzene, aldehydes, 1-3 butadiene, lead, particulate matter, hydrocarbon, oxides of sulphur and polycyclic aromatic hydrocarbons. While the predominant pollutants in petrol/gasoline driven vehicles are hydrocarbons and carbon monoxide, the predominant pollutants from the diesel based vehicles are Oxides of nitrogen and particulates (CPCB, 2010).

As per studies by Central Pollution Control Board (1998) vehicular emissions are responsible for most of hydrocarbons (90-95%) and carbon monoxide (70-80%) emissions.

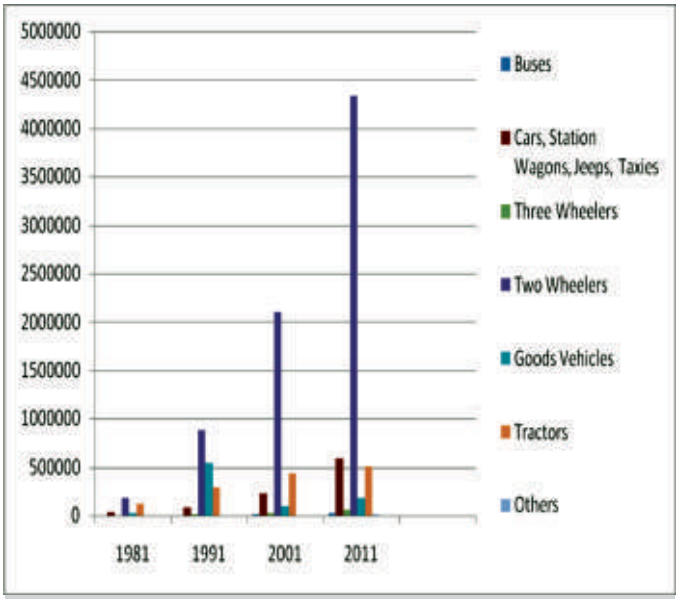
Fig 1. Increase in total no. of vehicles registered in Punjab during last four decades (1981-2011)



Source: Statistical Abstract of Punjab, 2012

Punjab has witnessed phenomenal growth in two wheeler segment, percentage of two-wheeled vehicles in the total number of motor vehicles increased from 49.02. In addition nitrogen oxides (around 40-60%) are also contributed by vehicles. In Punjab, the number of motor vehicles has increased from 3, 60,145 in 1981 to 57,11,715 in 2011 (Fig 1). Punjab has witnessed phenomenal growth in two wheeler segment, percent in 1981 to 75 percent in 2012 while share of buses declined from 7.50 percent to 0.5 percent during the same period. In 2011, personal transport vehicles (two-wheeled vehicles and cars & station wagons only) constituted 85 % of the total number of vehicles registered in the state (Fig 2). The total road length in the state has increased from 32,446 km in 1981 to 67,260 km in 2012 indicating a growth of road infrastructure to support increasing vehicular load.

Fig 2. Growth in different types of motor vehicles in Punjab (Number) from 1981-2011



Vehicle Type	1981	1991	2001	2011
Buses	5850	9470	16425	28377
Cars, Jeeps, Taxies etc.	33250	82799	226653	593282
Three Wheelers	2897	13550	29071	61433
Two Wheelers	176555	877837	2103526	4332540
Goods Vehicles	22092	544511	96703	179365
Tractors	118845	289064	434032	504310
Others	665	2351	3823	12408
Total	**360154**	**1329482**	**2910233**	**5711715**

Source: Statistical Abstract of Punjab, 2012

2. Industrial Growth

In past few decades, Punjab has seen rapid industrialization; consequently the total number of industries has increased tremendously. Main industrial centres in Punjab are Ludhiana, Jalandhar, Amritsar, Mandi Gobindgarh, Batala and Mohali. Ludhiana is known for the production of hosiery and ready made garments,

bicycles and components, sewing machines and parts, machine tools, auto-parts, industrial fasteners, electrical and electronic goods.

Industrial Pollution

About 21 per cent of the total industrial units in Punjab are located in Ludhiana district. Famous for hand tools, pipe fittings, valves and leather products, Jalandhar is well-known for its sports-goods too. Mandi Gobindgarh, popularly known as the 'Steel-Town' of Punjab, hosts more than 300 steel re-rolling mills despite being situated far from the sources of raw materials. Batala is famous in the country for its castings and machine tools, while Amritsar is known for food products, paper machinery and textiles.

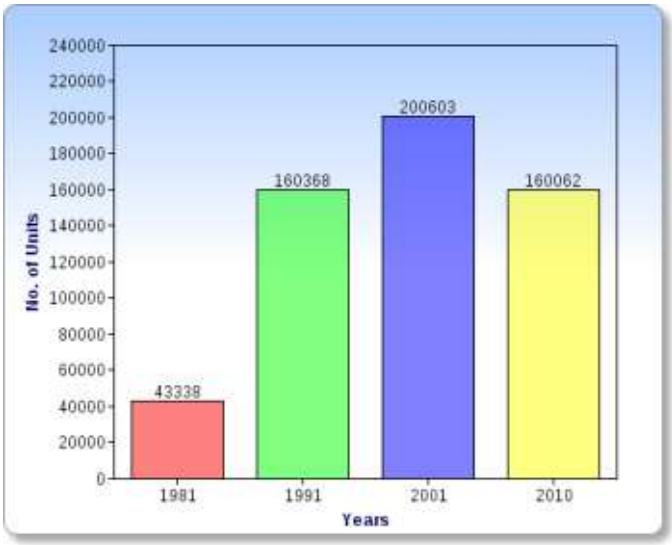
From analysis of statistical figures of growth in number of industries in the state between 1981 to 2010 it is observed that there is a fall in number of medium/large scale industry after 2001 (Fig 3). During 1981 there were 228 industrial units, 2001 show a steep increase in number of units i.e 629. As per Statistical Abstract of Punjab 2012, in 2010 total of medium/large industrial unit were 367. The industrial scenario in Punjab has suffered

Fig 3. Trend in growth of large and medium scale industries in Punjab (1980-2010)

Source: Statistical Abstract of Punjab, 2012

from the lack of modernization of the small scale units, which contribute about half of the total industrial production in the state. In 1981, total numbers of small scale industries in the state were 43,338, which rose to 2,00,603 units in 2001 (Fig 4). Next decade witnessed a steep fall in number of small industries as compared pervious decade when total no. of units in state were 1,60,062. Though number of industries has reduced, still industrial sector is considered as the major cause of air pollution, perhaps because of lack of state-of-art technology for energy efficient measures and air pollution control.

Fig 4. Trend in growth of small scale industries in Punjab (1980-2010)



Source: Statistical Abstract of Punjab, 2012

Table 2. Category wise air polluting industries in Punjab

Name of Industry	Major Air Pollutants
Rice, Sugar, Food Products	Particulates, CO_2, SO_2, NO_x
Beverages	Particulates, Odour
Cotton/Woolen/Synthetic/Textile/Dying etc.	Particulates
Paper Products & Printing	Particulates, mercaptans
Leather & Leather Products	Particulates, Odour
Rubber & Plastic Products	Particulates, Odour, VOCs
Chemical Products	Cl_2, HCl, Acid mist, Acid fumes, Hydrocarbons
Non-Metallic Mineral Products	Particulates
Metal Products	Metallic Particulates, CO, SO_2, Acid Mist
Transprt Equipments & Parts	Particulates
Brick Kilns	Particulates, SO_2, CO
Pharmaceuticals	Odour, Particulates
Rolling, forging & galanizing units	Particulates
Fertilizer, Vanaspati, Thermal, Cement, etc.	Odour, Particulates

Source: Tiwana et al., 2005

Various types of pollutants are emitted in the air from different types of industrial sources in the state are shown in (Table 2).

3) Agricultural Processes

The irrigated rice-wheat cropping system is the predominant and most profitable farming system in north-west India, especially in Punjab. About 90-95 percent of the area where rice is grown is also used for growing wheat in Punjab (Gadde *et al*., 2009).

Straw Burning in Fields

Many harvesting and post harvest activities are also responsible for air pollution especially in rural and peri-urban areas. These include:

- Spraying of chemical fertilizers and insecticides
- Processing of agricultural produce and wastes
- Burning of stubble in the fields after harvesting
- Fallowing in certain areas in dry season
- High rate of use of farm machinery like, tractors, combine harvesters, etc., with one tractor per 36.3 persons in rural areas and per 55.3 persons with respect to total population. (Tiwana *et al.* 2005).

There are growing concerns about the environmental effects of the system, particularly with the practice of burning rice stubbles. Widespread adoption of green revolution technologies and high yielding variety of seeds increased both, crop as well as crop residue. In the last few decades intensive mechanization of

agriculture has been occurring and combine harvesting is one such input, particularly in the rice-wheat system.

In rice-wheat system, a short period of time is available between rice harvesting and wheat plantation and any delay in planting adversely affects the wheat crop. This coupled with combine harvesting compels the farmers to burn the residue to get rid of stubble left out after the harvest. The state produces about 20 million tons of rice straw, and 17 million tons of wheat straw every year, a part of which (about 81% of rice straw and 48% of wheat straw) is burnt in the fields to make way for the next crop (Tiwana *et al.* 2007).

Burning of stubble releases a cocktail of ash, soot, acids and other damaging air borne particles. These chemicals are dispersible into the atmosphere. A study conducted by National Remote Sensing Agency in Punjab indicated that wheat crop residue burning contributed about 113 Gg (Giga Gram = 10 billion gram) of CO, 8.6 Gg of NOx, 1.33 Gg of CH_4, 13 Gg PM10 & 12 Gg of PM2.5 during May, 2005 and paddy straw/ stubble burning was estimated to contribute 261 Gg of CO, 19.8 Gg of NOx, 3 Gg of CH_4, 30 Gg of PM10 & 28.3 Gg of PM2.5 during October, 2005 (Badrinath *et al.*, 2006).

4) Domestic Processes

The continuous growth of population and resultant human activity in the state is also one of the major forces leading to air quality deterioration. Demographic data indicates that the population has gone manifold in the past three decades (from 16.78 million in 1981 to 27.70 million in 2011). With increase in population, pollution from different types of cooking stoves using coal, fuel wood, and other biomass fuels contributes to some extent, to the overall pollution load in any urban or rural areas.

Domestic Air Pollution by burning of Fuel Wood

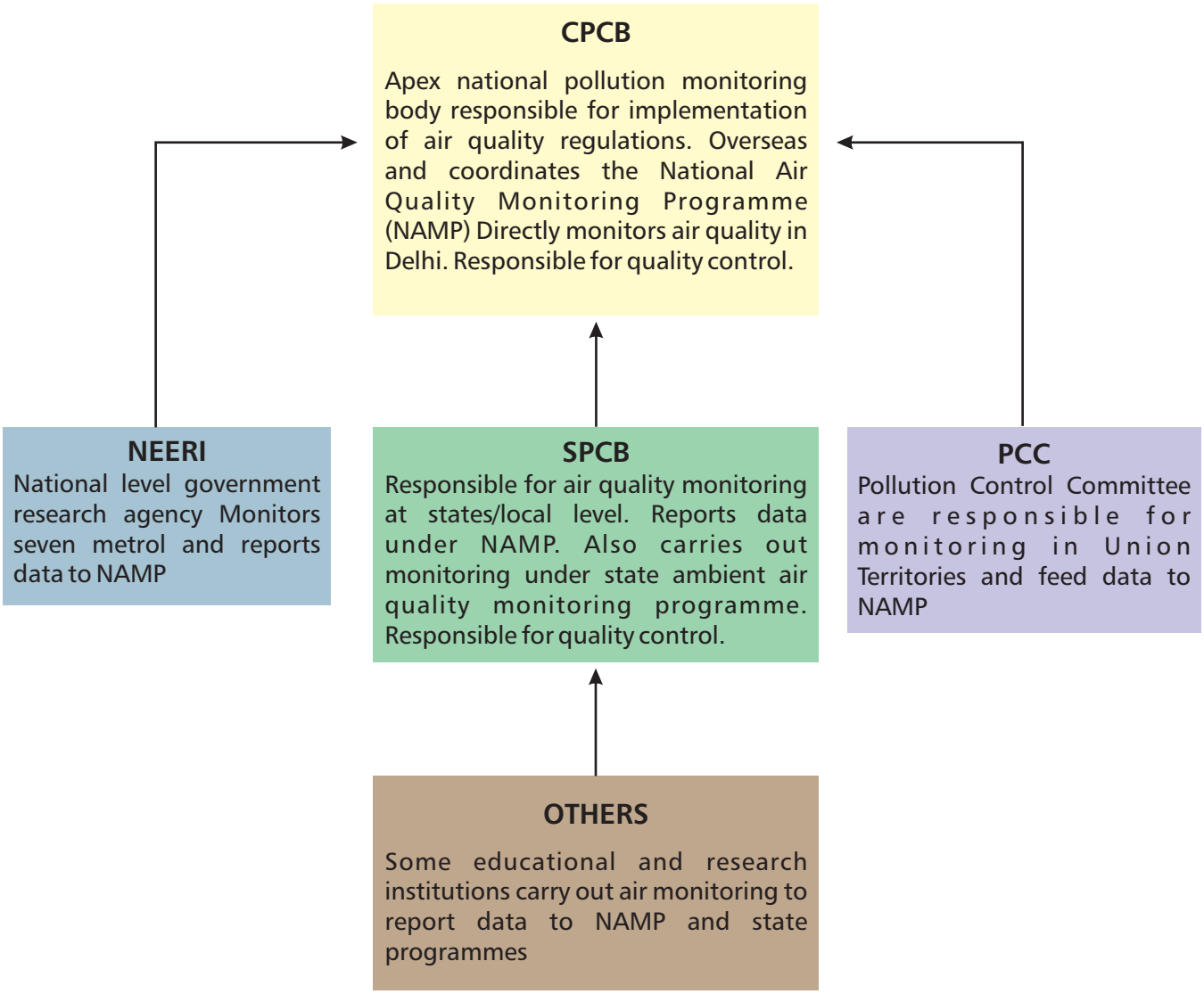
The main concern is the use of inefficient and highly polluting fuels in the poorer households leading to deterioration in indoor air-quality and health. Though LPG is the main source of domestic fuel in urban areas, however, in Punjab cattle dung cakes and fuel wood are still used in rural areas and slums. Further, due to high per capita income and adoption of modern life style, use of air conditioners and refrigerators in the state is increasing rapidly. This contributes to air pollution by ozone depleting substances. Further, since the state faces acute power shortage problem, use of diesel/kerosene gensets in domestic and commercial sector is rampant, adding one more source of air pollution.

AIR QUALITY MONITORING IN PUNJAB

At the state level, the responsibility to preserve environmental quality (Fig 5) vests with the

Fig 5. Institutional Framework

Fig 6. Air qaulity monitoring structure at India level



Source: Tiwana et. al., 2005

Department of Science, Technology and Environment through Punjab Pollution Control Board (PPCB) which is the main regulatory authority.

The Government of Punjab has declared the whole of the state as an Air Pollution Control Area and it is the responsibility of PPCB to ensure that the ambient air quality in the state is not deteriorated on account of air pollution caused by the various sources.

In addition to the above, Transport Department, Govt. of Punjab is also responsible for taking action for control of vehicular pollution whereas and the Municipal Corporations/Committee are responsible for control of pollution from municipal areas. Framework at national level is shown at (Fig 6).

Punjab Pollution Control Board (PPCB) is monitoring the air quality of various cities/ towns of the state under NAAQM (National Ambient Air Quality Monitoring) scheme financed by Central Pollution Control Board (CPCB) and AAQM (Ambient Air Quality Monitoring) scheme financed by State Government. The PPCB initiated monitoring of ambient air quality of the state under National Air Quality Monitoring Program (NAMP) at 5 locations in 1986. The number of

locations was increased to 12 in 1994, 15 in 1999, 19 in 2001. Presently, regular monitoring of ambient air quality is being carried out by PPCB at 23 locations (PPCB, 2013).Out of these, 9 stations are in residential/commercial areas, where as 13 locations are in industrial areas and 1 at Dera Baba Nanak, Gurdaspur for monitoring trans-boundary effects (Table 3).

Table 3. NAMP stations in Punjab

City	Station	Type
Mandi Gobindgarh	1. M/s Raj Steels	Industrial
	2. M/s Modern Automotives	Industrial
	3. M/s. United Steel	Residential /Commerical
Khanna	1. AS Higher Secondary School	Residential
	2. Markfed	Industrial
Ludhiana	1. Milk Plant, FerozepurRoad	Residential
	2. M/s. Nahar Spinning Mills	Industrial
	3. Vishwakarma Chowk	Commercial
	4. Zonal Office	Commercial
Jalandhar	1. Regional Office, PPCB	Residential
	2. Focal Point	Industrial
	3. Zonal Office, near M.C. Tubewell	Commercial
	4. M/s. G.K./ Maltex Malsters	Industrial
Naya Nangal	1. M/s. Punjab Alkalies	Industrial
	2. M/s. National Fertilizers Limited	Industrial
Dera Baba Nanak	1. C-PYTE Building	Trans-boundary Effects
Patiala	1. M/s. Ceylone Ind.	Industrial
	2. Fire Brigade Office	Commercial
Dear Bassi	1. M/s. Winsome Yarn	Industrial
	2. Ms. PCPL	Industrial
Bathinda Amritsar	1. M/s. Milk Plant	Industrial
	1. M/s. Vinod Milk Chilling Centre	Commercial
	2. R.O., Focal Point	Industrial

Source: PPCB, 2013

Till 2002, three pollutants monitored under this program were Suspended Particulate Matter (SPM), Sulfur dioxide (SO_2) and Nitrogen oxides (NO_x). Monitoring of Respirable Particulate Matter (RSPM) was initiated in 2002.

AIR QUALITY OF PUNJAB: STATUS AND TREND

Analysis of recent data provided by PPCB of all the monitoring stations of Punjab reveals that the annual average of RSPM at all industrial areas was higher than the permissible limit of 60 $\mu g/m^3$ as per NAAQS. In 2012 (Table 4), annual average value of RSPM was observed maximum at M/s Nahar Spining Mills, NAMP station at Ludhiana, M/s Raj Steels, NAMP station located in the city of Mandi Govindgarh, Fategarh Sahib was next most polluted town in term of RSPM.

Table 4. Annual averages (in ug/m^3)of SO_2, NO_x and RSPM in industrial areas (2012)

Name of Station	SO_2	NO_x	RSPM
M/s. Winsome Yarn Dera Bassi	10	27	128
M/s. PCPL, Dera Bassi	10	29	127
M/s. Raj Steels, Mandi Gobindgarh	09	36	232
M/s. Modern Automotives, Mandi Gobindgarh	08	34	134
M/s. National Fertilizers Limited, Nangal	07	18	88
M/s. Punjab Alkalies, Nangal	07	19	84
M/s. Milk Plant, Bathinda	07	30	167
M/s. Ceylone Industries , Patiala	07	19	93
Focal Point, Jalandhar	13	25	130
M/s. G.K./Maltex Malsters, Jalandhar	16	29	195
M/s. Nahar Spinning Mills Ludhiana	11	30	251
Markfed, Khanna	10	26	198
R.O, Focal Point, Amritsar	12	30	187

NAAQS Permissible annual limit (SO_2= 50 $\mu g/m^3$, NO_x=40 $\mu g/m^3$, RSPM=60 $\mu g/m^3$)

Source: PPCB, 2012

When annual averages of NOx is compared both the two monitoring stations of Mandi Gobingarh i.e. M/s. Raj Steels and M/s. Modern Automotives were found to be most polluted, having annual average of 36 $\mu g/m^3$ and 34 $\mu g/m^3$ respectively, although well within the permissible limit of 40 $\mu g/m^3$ (Table 4).

Analysis of last three year data of all these monitoring stations reveals that in both the monitoring stations located at Dera Bassi, Mohali i.e. M/s. Winsome Yarn and M/s. PCPL annual average of RSPM has shown a decreasing trend in past three years. For M/s. Winsome Yarn monitoring station (Fig 7 a) annual average of RSPM in 2010 was 140 $\mu g/m^3$, in 2011 it was recorded to be 98 $\mu g/m^3$, which rose to 128 $\mu g/m^3$ in 2012. In terms of concentration of SO_2, recorded data shows that there hasn't been much variation and concentration was found to be within permissible limits for M/s. Winsome Yarn monitoring station. M/s. PCPL monitoring station (Fig 10 b) also show same trend in terms of RSPM, in 2010 it was recorded to be 138 $\mu g/m^3$ and last year it was 127 $\mu g/m^3$. Concentration of SO_2 in last years has remained somewhat same. NO_x annual concentration at M/s. PCPL monitoring station has showed an increasing trend although concentration of both SO_2, NO_x was all within permissible limits.

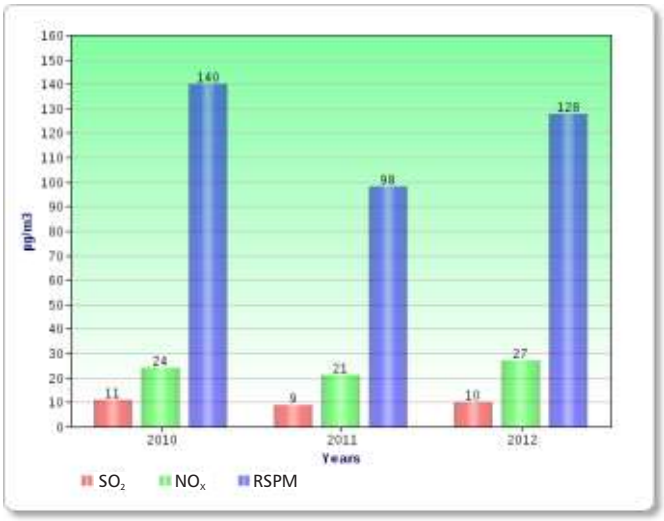
M/s. Raj Steel, Mandi Gobindgarh monitoring station (Fig 7 c) showed second highest value of annual average concentration of RSPM in the state i.e 232 $\mu g/m^3$. SO_2 concentration of this monitoring station was found to be within permissible limits and over the years has declined; it was recorded to be 18 $\mu g/m^3$, 13 $\mu g/m^3$, 9 $\mu g/m^3$ in 2010, 2011, and 2012 respectively. NO_x annual concentrations observed for this station in last three years is on higher side and close to permissible limit of 40 $\mu g/m^3$. Monitoring station located at M/s. Modern Automotives, Mandi Gobindgarh (Fig 7 d) also recorded higher concentrations of NO_x i.e 34 $\mu g/m^3$ in 2012, which was second highest value in the state. In terms of concentration of RSPM and SO_2 annual average concentrations has decreased over the last three years.

Annual average concentrations of both the monitoring stations located at Nangal, Roopnagar namely M/s. National Fertilizers Limited and M/s. Punjab Alkalies has shown decline in concentration of RSPM. Values of SO_2 and NO_x are within the permissible limits (Fig 7 e and Fig 7 f). Data from monitoring stations located at Bathinda and Patiala namely at M/s. Milk Plant (Fig 7 g) and M/s. Ceylone Industries, Patiala (Fig 7 h) shows a very positive decline in the concentrations of RSPM and SO_2. Although concentration of NO_x has increased over the last three years, but is well within the permissible limits.

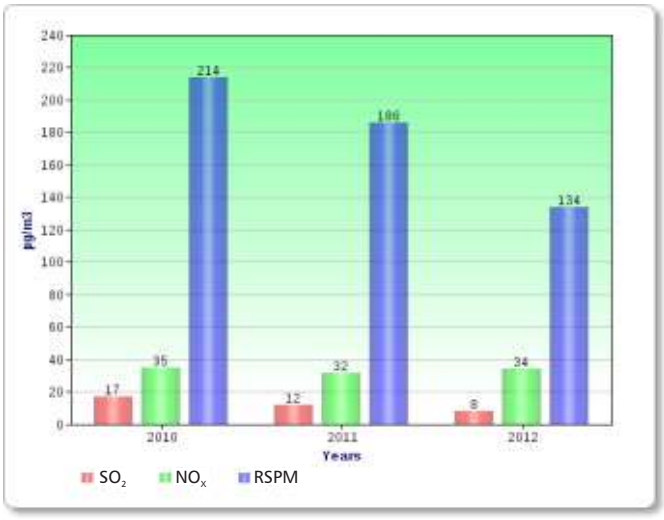
Industrial cities witness higher pollution level

Annual average concentration of RSPM of monitoring station located at M/s. Nahar Spinning (Fig 7 k) Mills, Ludhiana has decreased as compared to value of 2011, but still reading of 251 $\mu g/m^3$ is manifold above the permissible limits. Monitoring station at Markfed, Khanna (Fig 7 l) has also shown a decline in RSPM, SO_2, NO_x concentrations.

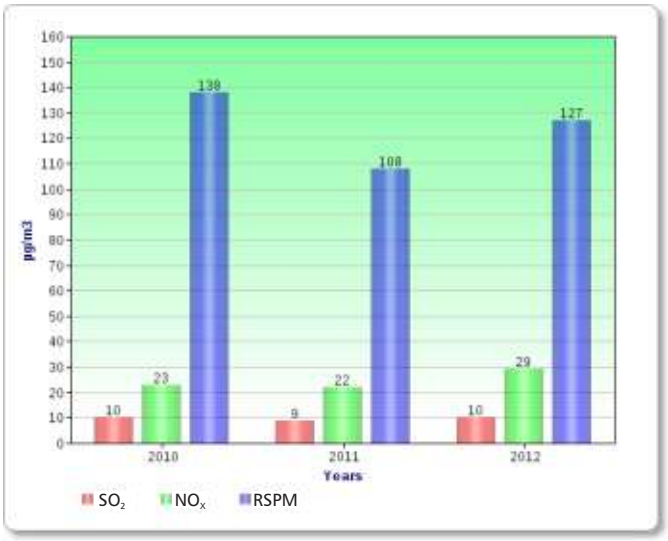
Fig 7 (a-l). Comparative trend of annual averages of SO_2 NO_x and RSPM



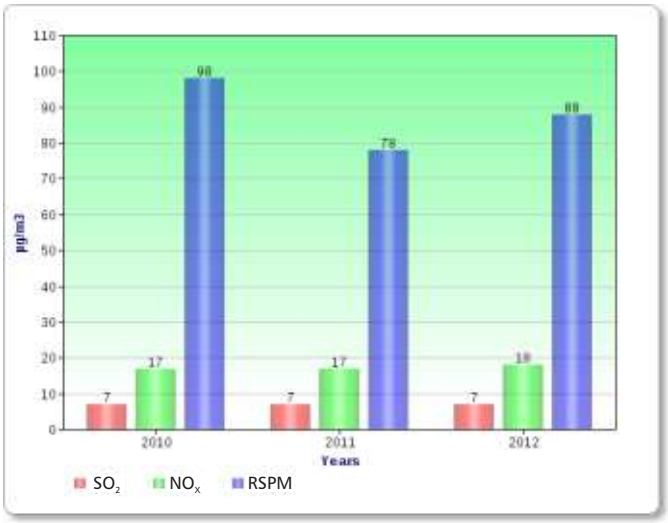
a) M/s. Winsome Yarn, Dera Bassi



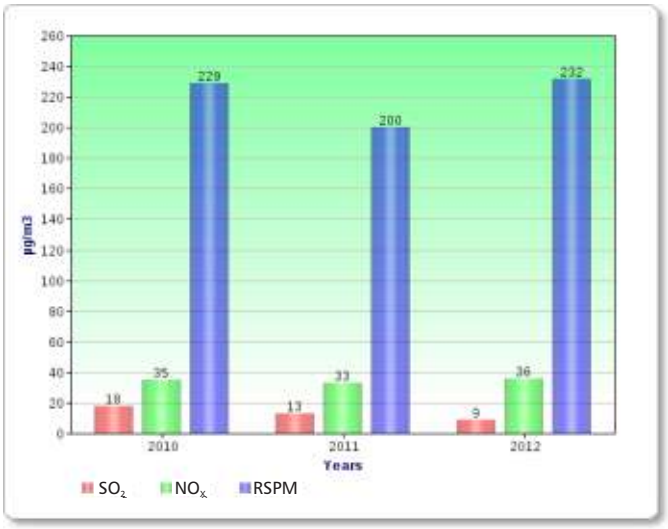
d) M/s. Modern Automotives, Mandi Gobindgarh



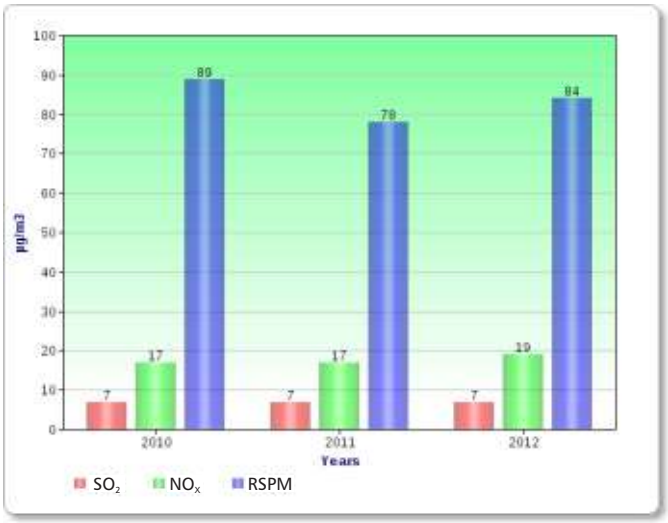
b) M/s. PCPL, Dera Bassi



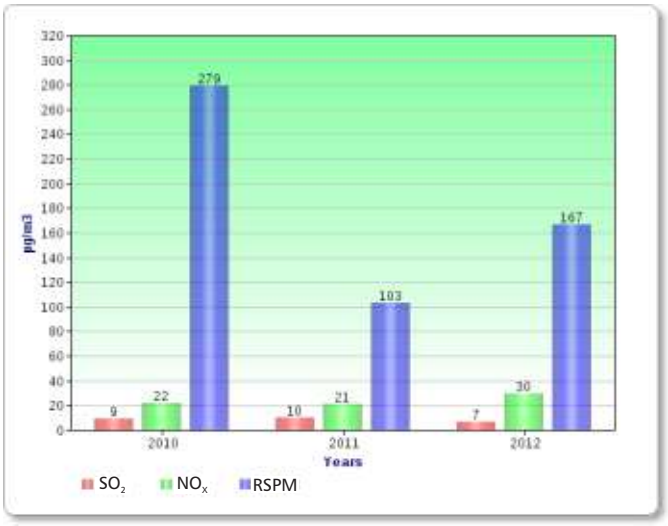
e) M/s. National Fertilizers Limited, Nangal



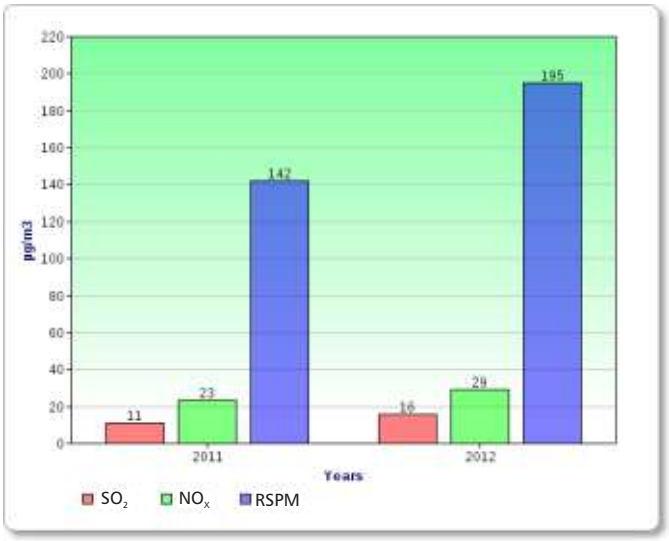
c) M/s. Raj Steels, Mandi Gobindgarh



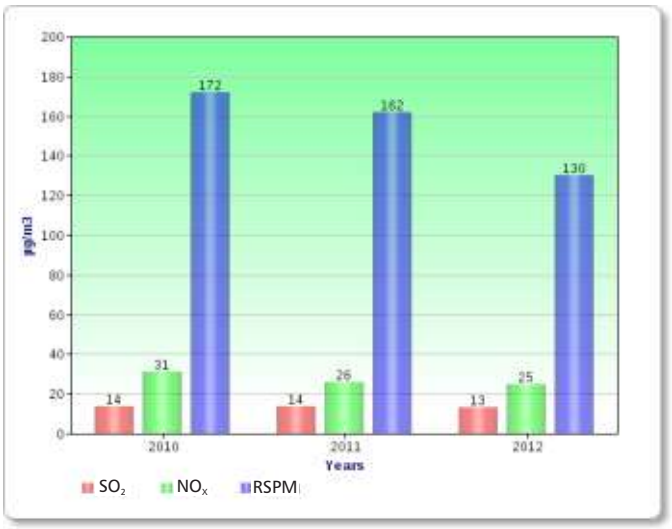
f) M/s. Punjab Alkalies, Nangal



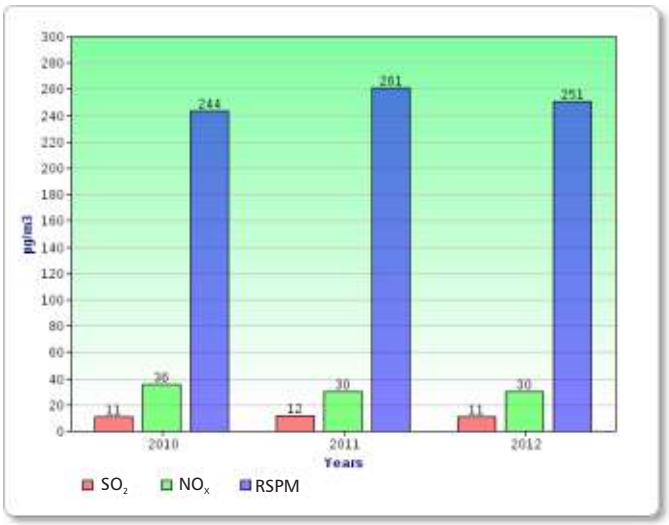
g) M/s. Milk Plant, Bathinda



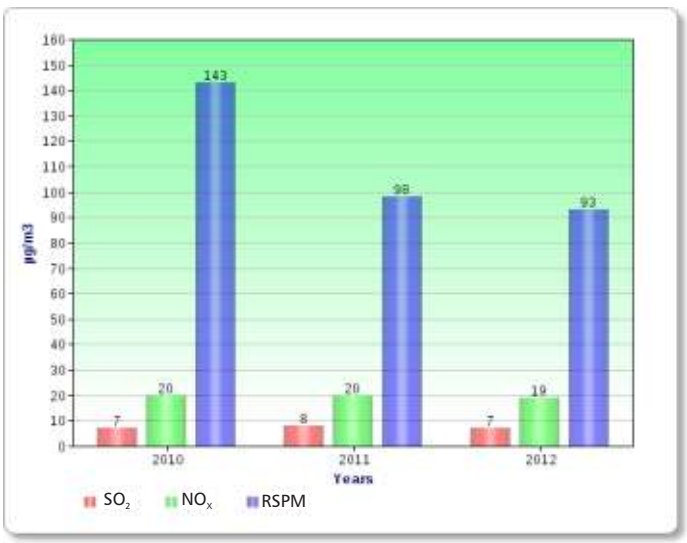
j) M/s. G.K./Maltex Malsters, Jalandhar



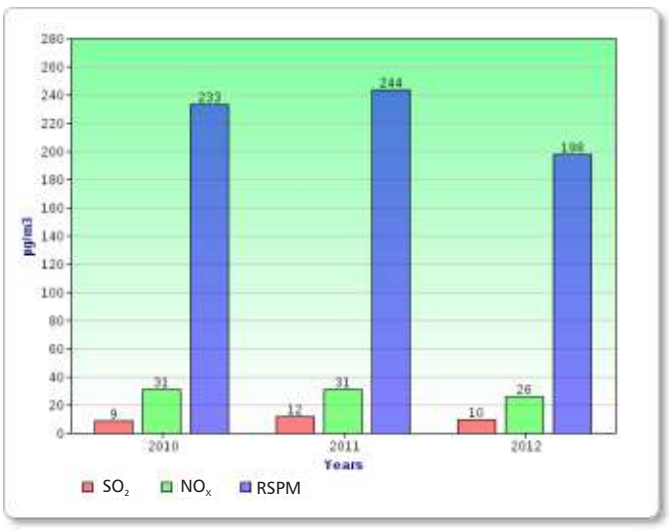
h) M/s. Ceylone Industries, Patiala



k) M/s. Nahar Spinning Mills, Ludhiana



i) Focal Point, Jalandhar



l) Markfed, Khanna

NAAQS Permissible annual limit (SO_2= 50 $\mu g/m^3$, NO_x=40 $\mu g/m^3$, RSPM=60 $\mu g/m^3$)

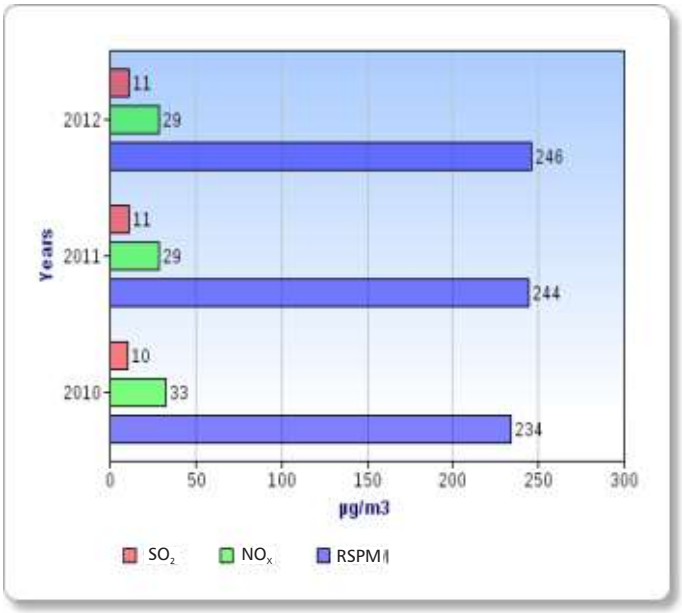
Source: PPCB, 2013

Analysis of data of all the monitoring stations located in residential-commercial areas shows that air of Ludhiana around Vishwakarma Chowk station had maximum RSPM value of 246 ug/m^3 in 2012 (Table 5). Comparison of three years data of Vishwakarma Chowk shows that value of annual average concentrations of RSPM has increased from 234 $\mu g/m^3$ in 2010 to 246 $\mu g/m^3$ in 2012, likewise concentration of NO_x has also increased in this area (Fig 8).

In 2011, World Health Organization (WHO) declared Ludhiana as the most polluted city in the India and again in 2013, WHO declared Ludhiana as the second most polluted city (with 251 $\mu g/m^3$ as annual average for RSPM) in Asia Pacific region after Ulan Bataar, Mangolia (www.traveldailynews.asia/). Concentrations of NO_x and SO_2 in all the monitoring stations have found to be within the permissible limits.

Vinod Milk Chilling Centre of Amritsar showed maximum value for NO_x in the state i.e. 39 $\mu g/m^3$ almost touching the permissible limit of 40 $\mu g/m^3$ whereas Raj Steels and United Steels monitoring station of Mandi Gobingarh recorded value of 36 $\mu g/m^3$. Value of RSPM levels recorded from all monitoring stations have been reported to be above permissible limits in two most polluted cities of the state namely, Mandi Gobindgarh and Ludhiana with respect to annual averages (Table 6). A comparison of RSPM data with their respective permissible limits indicates that the concentrations of RSPM are way beyond the permissible limits at all the monitoring stations in these cities (Fig 9 & Fig 10).

Fig 8. Annual average concentrations at vishwakarma chowk station (2010-12)



Source: PPCB, 2013

Table 5. Annual averages of SO_2, NOx and RSPM in residential/commercial areas (2012)

Name of Station	SO_2 $\mu g/m^3$	NO_x $\mu g/m^3$	RSPM $\mu g/m^3$
Fire Brigade Office, Patiala	8	22	104
M/s United Steels, Mandi Gobindgarh	10	36	230
R.O, Jalandhar	13	25	130
Z.O. near MC Tubewell, Jalandhar	13	26	140
Milk Plant, Ludhiana	9	21	213
Z.O, Ludhiana	10	291	84
Vishvakarma Chowk, Ludhiana	11	29	246
A.S. Secondary School, Khanna	10	26	186
Vinod Milk Chilling Centre, Amritsar	13	39	196

NAAQS Permissible annual limit (SO_2= 50 $\mu g/m^3$, NOx=40 $\mu g/m^3$, RSPM=60 $\mu g/m^3$)

Source: PPCB, 2012

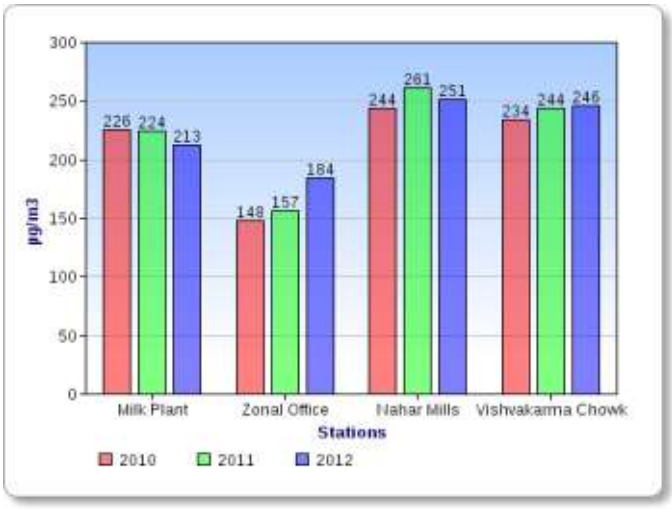
Table 6. Annual average of all NAMP monitoring stations (2012)

NAMP Monitoring Stations	Pollution level ($\mu g/m^3$)		
	RSPM	No_x	So_2
Mandi Gobingarh			
Raj Steels	232	36	9
United Steels	230	36	10
Modern Automotives	134	34	8
Khanna			
AS Higher Secondary School	186	26	10
Markfed Vanaspati	198	26	10
Ludhiana			
Milk Plant	213	21	19
Nahar Spininng Mills	251	30	11
Vishwakarma Chowk	246	29	11
Zonal Office	184	29	10
Jalandhar			
PPCB, RO	130	25	13
Focal Point	130	25	13
Zonal Office Building	140	26	13
Punjab Maltex	195	29	16
Nangal			
Punjab Alkalies	84	19	7
National Fertilizers Limitec	88	18	7
Dera Baba Nanak			
C-PYTE Building	70	12	7
Dera Bassi			
Winsome Yarn	128	27	10
PCPL	127	29	10
Bathinda			
Milk Plant	167	30	7
Amritsar			
Vinod Milk Chilling Centre	196	39	13
Regional Office Building	187	38	12
Patiala			
Fire Brigade office	104	22	8
Ceylone Industries	93	19	7

NAAQS Permissible annual limit (SO_2= 50 $\mu g/m^3$, NOx=40 $\mu g/m^3$, RSPM=60 $\mu g/m^3$)

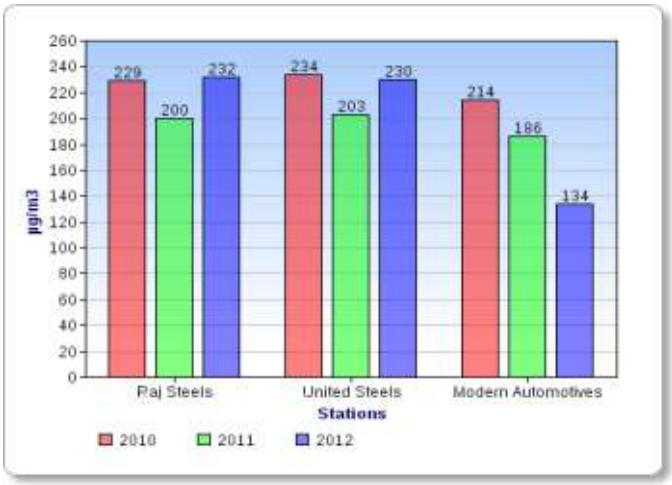
Source: PPCB, 2012

Fig 9. Annual average concentration of RSPM in all monitoring stations of Ludhiana (2010-12)



Source: PPCB, 2013

Fig 10. Annual average concentration of RSPM in all monitoring stations of Mandi Gobindgarh (2010-12)



Source: PPCB, 2013

The MoEF, Govt. of India, had imposed the moratorium on 43 critically-polluted areas of the country, including two cities of Punjab; Mandi Gobindgarh and Ludhiana. Moratorium was imposed on environmental clearance for new projects (and expansions) in order to stimulate environmental remediation/mitigation activities by industry and by the state governments concerned. The process started in 2009, when the MoEF had asked the Central Pollution Control Board (CPCB) to carry out a comprehensive

environmental assessment of 88 important industrial clusters. This assessment which was released on December 24, 2009 was based on the Comprehensive Environmental Pollution Index (CEPI) developed by a number of prominent academic institutions, led by IIT-Delhi. However, MoEF lifted moratorium imposed on Mandi Gobindgarh in October 2010 and in March 2011 ban on Ludhiana was lifted. It was decided that during the period of moratorium, time-bound action plans would be prepared by the industries and the state pollution control boards to improve environment quality of these units.

Air Pollution in Ludhiana

In 2012, PPCB carried out a study to access contribution of vehicles in air pollution in the city of Ludhiana and had earmarked five most traffic prone areas, including Bharat Nagar Chowk, Jagraon Bridge, Bus Stand, Samrala Chowk and Dholewal Chowk. The experts on the basis of samples of RSPM, SO_2 and NO_x found that the Jagraon Bridge area to be one of the most polluted part of the city where 348 $\mu g/m^3$ of air was found to be polluted during day time, three time more than the permissible limit (*The Tribune, 4th Oct, 2012*).

AMBIENT AIR QUALITY DURING DIWALI DAYS

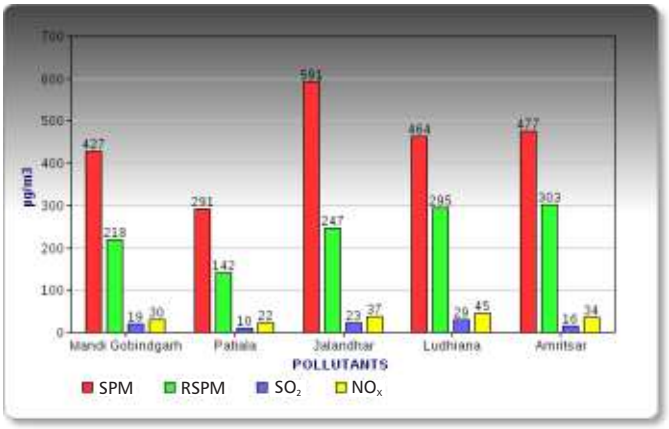
People in Punjab celebrates festivals like Dushehra, Diwali, Gurupurv, New Year, etc. by

Diwali Celebration in Amritsar

lighting lot of fire crackers/fireworks and try to out do each other. This trend of celebration, therefore, affects ambient air quality and noise levels during festive season particularly during Diwali. Fireworks contain harmful chemicals such as potassium nitrate, carbon and sulphur apart from an array of chemicals such as strontium, barium, sodium, titanium, zirconium, magnesium alloys, copper and aluminum powder to create the colourful effects (Holmes, 1983). On burning firecrackers release gases such as carbon monoxide (CO) and nitrogen dioxide (NO_2) (Khaiwal *et al.,* 2003). High level of SPM/RSPM, SO_2, NO_x and above all noise due to bursting of high intensity crackers are of serious environmental concern both from the point of view of public annoyance and public health.

During the period 2010-2011, the PPCB conducted a study to assess the impact of Diwali day celebration on the quality of air with respect to the suspended particulate matter, obnoxious gases like nitrogen oxides, sulfur dioxides and high noise levels. Sulphur dioxide and Nitrogen oxides samples were collected each day for 24 hrs from NAMP monitoring stations. (Fig 11) shows that in 2010, city of Jalandhar witnessed maximum SPM (591 $\mu g/m^3$) concentration during Diwali night, whereas concentration of SO_2 (29 $\mu g/m^3$) and NO_x (45 $\mu g/m^3$) was maximum in Ludhiana, city of Amritsar witness maximum RSPM (303 $\mu g/m^3$).

Fig 11. Air quality monitoring on Diwali night, 2010



	Mandi Gobindgarh	Patiala	Jalandhar	Ldh.	Amritsar
SPM	427	291	591	464	477
RSPM	218	142	247	295	303
SO_2	19	10	23	29	16
No_2	30	22	37	45	34

All value in $\mu g/m^3$

Source: PPCB, 2010

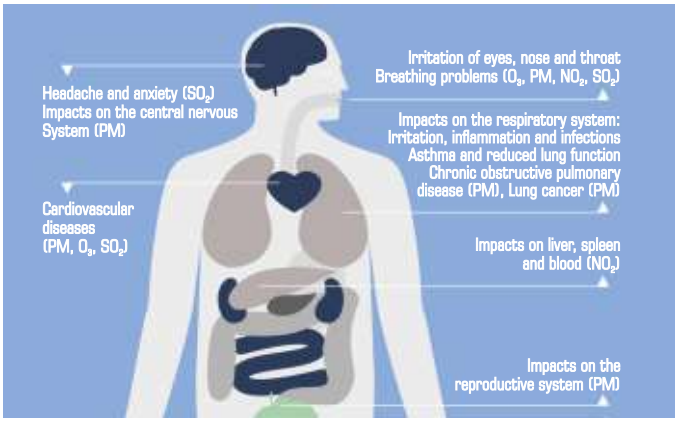
PPCB data of 2012 show that there is an increase of RSPM level in the city of Amritsar between pre-Diwali monitoring and on the day of Diwali . In 2012 RSPM on Diwali night was recorded to 201 $\mu g/m^3$ higher than pre-Diwali monitoring as compared to the corresponding increase of 195 $\mu g/m^3$ in 2011. The samples of pollutants recorded around Golden Temple on Ambient Air Quality Monitoring System device during pre-Diwali monitoring on November 6, 2012 showed RSPM levels at 189 $\mu g/m^3$, which increased to 390 units on Diwali day.

In the city of Amritsar in 2011, the increase was 195 points, when pre-Diwali (on 21 October, 2011) and Diwali day (on 26 October, 2011) monitoring figures of RSPM were 207 $\mu g/m^3$ and 402 $\mu g/m^3$, respectively. Not only RSPM, other pollutants like NO_x and SO_2 also registered an increase as compared to pre-Diwali and Diwali day monitoring. The increase in NO_x in 2012 between pre-Diwali monitoring and on the day of Diwali was 19 points, as compared to 11 points previous year. Sulphur Dioxide increase was 14 points as compared to 13 points last year. Even noise level increased by a point in 2012 as compared to 2011.

IMPACTS OF AIR POLLUTION

Epidemiological studies show that the contamination of air quality increases adverse health impacts (Ostro *et al.* 1995). Air pollution contributes to the respiratory diseases like bronchitis, emphysema, asthma, also eye irritation etc., which not only increases individuals' diseases mitigation expense but also affect their productivity at work. Most of the studies valuing health impacts of air pollution remain confined to urban areas as air pollution is considered mainly the problem of urban areas in developing countries.

The World Health Organization (WHO) has estimated that urban air pollution is responsible for approximately 800,000 deaths and 4.6 million people lost 'life-years' each year around the globe (WHO, 2002). Among the motor vehicle-generated air pollutants, diesel exhaust particles account for a highly significant percentage of the particles emitted in many towns and cities. Acute effects of diesel exhaust exposure include irritation of eyes and nose, lung function changes, headache, fatigue, and nausea. Chronic exposure is associated with cough, sputum production, and lung function decrements. (Jain, *2012*).



Impact of Air Pollution on Human Health

Though health consequences from burning of agricultural residue are not fully understood, relative short exposure may be more of a nuisance rather than a real health hazard. Many of the components of agricultural smoke cause health problem under certain conditions (Long *et al,* 1998). The general impacts of air pollution are presented in Table 7.

Table 7. Health effects of major air pollutants

Nature of Pollutant	Effects on Human Health
Suspended Particulate Matter (SPM)	Irritant, affects lungs & bronchii. Can be carcinogenic.
Oxides of Sulphur (SO_x)	i) Irritant, affecting mucous membranes. ii) Causes servers bronchospasms at low levels of SO_3. iii) SO_2 levels at 400-500 ppm dangerous even at short term exposure.
Oxides of Nitrogen (NO_x)	Eye & nasal irritation occurs after exposure of 15 ppm of NO_2 & pulmonary discomfort after exposure to 25 ppm.
Carbon Monoxide (CO)	i) Tendency to combine with hemoglobin in blood forming carboxy-haemoglobin which reduces oxygen supply to body tissues. ii) Affects central nervous system responsible for heart attacks & high mortality rates.
Ozone (O_3)	Irritates the respiratory tract.
Lead (Pb)	Causes gastrointestinal damage, liver & kidney damage, abnormalities in pregnancy and affects mental development of children.

Source: Adapted from Stern, 1968

The haze because of air pollution results in decreased visibility, decreased photosynthesis, and enhanced atmospheric deposition (Agrawal S., 2008). All these adversely affect wildlife and vegetation besides particulates and acidic gases result in general aesthetic damage. Impact of major air pollutants on plants are given in Table 8.

Table 8. Impacts of air pollutants on plants

Pollutant	Major Source	Major Impacts
Suspended particulate Matter (SPM)	Transport, power generation, industry, domestic heating	Reduced plant growth, low productivity & chlorophyll content, encrustation on leaves
Sulphur dioxide (SO_2)	Power generation, industry, commercial & and domestic heating	Visible foliar injury, altered plant growth, elimination of lichens & bryophytes, forest decline due to acid rain.
Nitrogen oxides (NOx)	Power generation, transport	Reduced plant growth
Ozone (O_3)	Secondary pollutant formed from NOx and hydrocarbons	Visible foliar injury, reduced plant growth.
Fluorides	Manufacturing & smelting industries	flourosis in Reduced plant growth, grazing animals

Source: Emberson et.al., 2003

RESPONSES TO MITIGATE AIR POLLUTION IN THE STATE

A. Legislative & Policy responses

- The Punjab Pollution Control Board was set up on 30.07.1975. It initiated monitoring of ambient air quality in Punjab in 1986 at 5 locations. These have now been increased to 23. The Board has also undertaken various studies on pollution caused by various point sources and formulated time-targeted action plans to reduce pollution in Ludhiana and Mandi Gobindgarh. It is

making efforts to promote industrialization in the state along with clean environment.

- The Environment (Protection) Act, 1986 & The Motor Vehicles Act, 2000; and Rules notified under the above, as amended; and all other Central Government legislations are being implemented in Punjab.
- The whole of the state of Punjab has been declared as Air Pollution Control Area vide notification no. G.S.R. 22/C.A 14/81/S 54/ and (2) 88, dated 2.3.1988.
- Under the Motor Vehicles Act, 1990 each vehicle is required to obtain 'Pollution Under Control' certificate as per existing norms. Test equipments have been approved by the State Government for use by authorized agencies and pollution monitoring facilities are available at petrol pumps and vehicle repair & maintenance units. A total of 421 pollution checking centres are functioning in the State of Punjab to check the emission of vehicles and to issue pollution under control certificates to motor vehicles of all types, so as to keep the environment free of pollutants released by diesel and petrol operated vehicles (punjabtransport.nic.in).
- The Board is taking necessary steps to ensure that emission standards specified by Government of India with respect to major air polluting categories of industries are complied with, by providing adequate pollution control measures. It takes legal action against the defaulting units.
- Punjab is the only state in the country which, after detailed study, has banned the burning of rice husk in the boiler furnaces in loose form (except in Fluidized Bed Combustion System) w.e.f. 01.04.1995.
- Burning of rubber in any form has also been banned since 1.4.1994.
- Burning of Process wastes containing sulfur and toxic substances is also banned with effect from 1.4.1994.
- A state level crisis group has also been set up to deal with air pollution accidents in the state.
- The Industrial Policy of Punjab is trying to ensure that clearances for Pollution Control from green category industries are granted within a week and for red category industries within a week by Industries department and within a month by PPCB.
- PPCB has taken the initiative and conducted a scientific study for making PET COKE as an authorized fuel for use in the boiler furnaces and suggested the air pollution control devices and other measures to be taken to control sulfur dioxide emissions. A Notification, in this regard, has already been issued.
- Capacity building of owners & workforce in brick kilns and re-rolling mills through on-site and off-site training programms are being conducted by PSCST for sensitizing the stakeholders on energy conservation and pollution reduction measures. More than 3000 SMEs have been benefitted from these programs.
- Training programs for specific industries and other target groups are conducted by PSCST regularly.
- The State Government has constituted the Competent State Authority (CSA) for critical scrutiny and site appraisal of new industry in

Rolling Mill with APCD

Table 9. Status of use of APCDs in the state

	Large & Medium (No. of Unit)		Small Scale Industries (No. of unites)		Categories (No. of unites)		
Year	With APCD	Without APCD	With APCD	Without APCD	Red	Orange	Green
2002-03	396	-	6942	925	9068	-	4912
2008-09	394	-	7216	169	10753	-	7867
2009-10	507	-	9027	116	12238	-	9289
2010-11	489	-	9585	74	12877	25*	83*
2011-12	496	01	10106	84	13070	679	5860**

**This information is for large and medium scale industries only*
***Information is for operating units in the State and not includes the figures of regional office, S.A.S.Nagar.*

Source: PPCB, 2012

the state. An industry desirous of setting up a unit in Punjab needs to submit required documents to the CSA. Details of consent to establish industry granted in 2011 is shown in Table 10.

B. Infrastructural responses

i. *Industrial Pollution Control:*

- With the aim of promoting planned industrial growth, the state government has set up Punjab State Industrial Development Corporation and Punjab Small Industries Export Corporation. Several focal points, industrial estates, industrial areas and industrial growth centres have been set up in the state. The main purpose of developing these Corporations is to encourage industrial growth at locations centrally linked by transport, communication & water and power supply and to confine industrial activities in specific areas only to ensure environmental friendly development. PPCB has identified 13070 industrial units as Red Category, 679 as Orange and 5860 as Green category industries. Status of Air Pollution Control Devices (APCDs) installed in industrial units of the state is given in Table 9.
- Pulverized coal and furnace oil are being promoted instead of coal wherever possible eg. in Mandi Gobindgarh.
- PPCB makes available cost effective technologies & sets up model demonstration plants for control of pollution in small scale units such as cupola furnaces, rice shellers, and induction furnaces etc., with the help of PSCST, Chandigarh.
- Advisory Role: Beside punitive actions the government has also adopted the policy of persuasion to industries. A Consultancy Cell has been set up in Punjab State Council for Science & Technology to provide consultancy to small scale units (Box 5). The Consultancy Cell develops, demonstrates & promotes low cost environmental friendly technologies. It has prepared process packages for important small scales

Table 10. State government consent to established industry in Punjab during 2010-11

Consent to Establish Industry	Red	Orange	Green
Granted	454	42	183
Refused	10	0	0

Source: PPCB, 2012

industries in Punjab such as brick kilns, rice shellers, cupola furnaces, induction furnaces & rolling mills (Table 11).

Box 5. Services offered by consultancy cell of PSCST

- Pollution control & energy conservation
- Capacity building of owners & welfare
- Promotion of energy efficiency in industrial and construction sector
- Energy audit of industrial buildings & SMEs.

Source: PPCB, 2012

Table 11. Energy conservation and pollution control techniques suggested in different air polluting industries in Punjab

Industry Type	Pollution & Energy Conservation	Benefits
Cupola furnaces (less than three tonnes/hour)	• Improvement of metal coke ratio • Wet scrubber	• 40% saving in coke • Pay back period : 10 heats
Induction furnaces	• Effective suction of emission • Effective control of particulate emission with scrubber or filtration unit	• Effective & workable containment-cum-control system
Rice Shellers	• Containment of particulate emission & Pollution control using high efficiency cyclone separator	• No additional power • Considerable improvement in quality of bran
Re-rolling mills (coal fired)	• Cyclone followed by scrubber • Heat exchanger • Insulation of furnace • Better pulverization	• 10-20% coal savings
Brick Kilns	• Better feeding, firing & Operating practices	• 10-15% coal savings • Better quality of bricks
Energy efficient kilns	• Gravity setting chamber	

Source: Adapted from Tiwana et al, 2005

ii. Vehicular Pollution Control:

- Lead free petrol was introduced in Punjab in 2000.
- In July 2012, the high court had directed the state government to take decision at an appropriate level regarding use of compressed natural gas (CNG) as an alternative fuel for public transport, including auto-rickshaws, especially in Amritsar, Jalandhar and Ludhiana.
- The road network is well developed and roads are relatively good. This helps smooth flow of traffic and thus reduces vehicular emissions.
- Studies have been conducted by PPCB for monitoring and assessment of vehicular and noise pollution.
- Tree plantation drives have been taken up along all major roads throughout the state.

iii. Air Pollution control from Municipal & Commercial Sources

- There are 137 Municipal Bodies in the State of Punjab (Annual Report, PPCB 2008). The Department of Local Government, Punjab has taken a major initiative in developing integrated MSW processing plants across the State in Public Private Partnership (PPP) format. This initiative has been successful in controlling open burning of municipal waste. Under the project, the State of Punjab has been divided into eight clusters viz Amritsar, Bathinda, Ferozepur, Jalandhar, Ludhiana, Patiala, Pathankot & GMADA. Each cluster comprises of a major town and other peripheral towns. Solid Waste Management would comprise of cluster wise door to door collection, a central integrated processing plant and scientific landfill site along with transfer stations.
- The Punjab Energy Development Agency (PEDA) has provided Solar energy appliances, Improved chullahs, bio-gas plants *etc.* to reduce air pollution.

iv. Air Pollution control from agricultural sources

- The Govt. of Punjab has prohibited the indiscriminate burning of left over paddy and wheat straw/stubble in the whole of state with immediate effect vide notification No. 3/162/2006-STC (4)/946 dated 22.10.13
- To curb burning, the Agriculture Department is promoting zero tillage technology. According to this technology, burning of crop residue is prevented by promoting mulching and residue management. Wheat seeds are sown on areas still under rice crop residue by placing them directly into narrow slits without tilling of fields.
- Promotion of 'The Happy Seeder technology', as it allows direct drilling of wheat in standing as well as loose residues thus, avoiding field burnig of paddy stubble.

C. Awareness Programmes

- Regular awareness campaigns are conducted by the Punjab State Council for Science & Technology through NGOs and schools. Punjab Pollution Control Board also conducts awareness programs for specific target groups.

School Awareness Programme

- In each district 250 Eco clubs have been set up in schools under the National Green Corps project which takes up environmental awareness activities.

On Site Training of Industry People

SUGGESTIONS

In addition to aforementioned actions taken by the state government, new initiatives are needed for control of air pollution in the state. Sector wise implementation of following inputs would help in making air quality better:

a) Agriculture

- Mobilizing farmers to reincorporate stubble in soil and avoid its burning.
- Provide incentive and subsidy to innovative farming methods already present to avoid stubble burning and promote alternative uses of paddy straw.

b) Vehicular

- Vehicles running on old engines must be phased out from all the cities of Punjab.
- Introduction of CNG vehicles.
- Intra-city public transport system may be put in place to discourage frequent use of private vehicles.
- Effective traffic management for easy flow of traffic so as to reduce burning of fuel and corresponding emissions into the atmosphere.
- Segregation of slow & fast moving traffic may be taken up.

- Emphasis on development of road network which will help in smooth flow of traffic and this would reduce vehicular emissions.
- Tree plantation drives should be taken up along all major roads and railway tracks throughout the state.
- Flyovers may be given preference.
- Mass Rapid Transport System may be planned especially in bigger cities like Ludhiana, Amritsar & Jalandhar.

c) Industrial

- Development of modern specified industrial areas and focal points with state of art technologies to minimize air pollution.
- Cleaner & energy efficient technologies and waste minimization in industry needs to be given priority.
- Incentives may be provided to promote waste utilization technologies.
- No residential areas should be allowed within a specific distance around an industrial area.

d) Domestic

- Use of better fuel, promotion of solar energy appliances, improved chullahs, bio-gas plants etc. to reduce air pollution in the state.
- Awareness drives for household ladies and workers to educate them to reduce air pollution.
- Epidemiological studies should be promoted especially in highly polluted areas.
- Training & education for governmental agencies, industry, students and public be promoted.

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NEWS

Green national accounts to be at state level initially

New Delhi : The Green national accounts system for taking into account the environmental costs of economic development would be implemented at state level initially, a government official said today.

"It will be largely at the level of the state. Later on, it can go finer, we will have to engage with the states to figure out what will it take to implement," chief statistician and secretary, statistics and programme implementation ministry TCA Anant told reporters on the sidelines of an event here.

Government in 2011 had constituted an expert group under the chairmanship of Pratha Dasgupta from the Cambridge University to develop a framework for green national accounts, identification of data gaps and preparation of a road map for its implementation. Yesterday, Prime Minister Manmohan Singh released the report prepared by the expert group. The system of green national accounting would take into account the environmental costs of development and reflect the use of precious depletable natural resources in the process of generating national income. Anant said the government will need data on forest, minerals, water, land, air quality, pollution to prepare a comprehensive data base. Creation of "asset account" under this will hugely require this kind of data, he said.

"The important areas are different for different states, you have to allow that differentiation also in the framework so that different states will pick up different elements," he said.

He also said recommendations have been made to the Finance Commission so that states start compilation of data.

"We have in the recommendations to the Finance Commission, that the states should start measuring things. Once it is filtered through the various processes of the government, various agencies of the government will take note of this and they will start incorporating it," he said. The need for green national accounts emerged as there was a growing recognition that contemporary national accounts were becoming unsatisfactory basis for economic evaluation, the report said. "The qualifier 'green' signals that we should be especially concerned about the absence of information on society's use of the natural environment," the report added.

Source: April 6, 2013, The Economic Times

Smoke-free status for Sangrur district on cards

Sangrur : As Sangrur is heading towards attaining smoke-free district status, the health authorities here have strictly directed owners of hotels having 30 or more rooms and restaurants or eateries having a seating capacity of 30 or more to set up designated smoking areas.

However, in a hotel having less than 30 rooms and a restaurant having a seating capacity of less than 30 persons, smoking is strictly prohibited. This direction has been issued under the Cigarette and Other Tobacco Products Act (COTPA) to isolate smokers from non-smokers as there is prohibition on smoking at all public places under Section 4 of the COTPA. The authorities have stated that owners of such hotels or restaurants would have to face the music for violating rules of the COTPA as they have made up their mind to check smoking in a big way. This is being done with the aim of protecting non-smokers from the hazards of passive smoking.

A team from the PGI, Chandigarh, will visit Sangrur district in the first week of May for a compliance study to declare Sangur a smoke-free district.

It has been stated that the team will check there is no active smoking at any public place in the district.

Talking to The Tribune, District Health Officer-cum-district nodal officer, Tobacco Control, Dr Surinder Singla said if during surprise checking any type of ash tray or cigarette/'beeri' butts were found in any hotel or restaurant, it would be considered a violation of the COTPA.

Dr Singla said if the manager, in charge or owner of a public place, failed to act or report the violation of the COTPA, he would be liable to pay fine corresponding to the number of individual offenders smoking there at that time. The hotel and restaurant owners had also been directed to ensure display of 'No smoking' signboards at the entry and exit points and inside sitting halls, he added.

During the first three months of this year, as many as 468 challans were issued for smoking at public places in the district as compared to 125 challans in the corresponding period the previous year.

Source: April 26, 2013, The Tribune

IMPORTANT EVENTS

Air Pollution 2013

3rd to 5th June 2013

Venue: Siena, Italy

Website: http://www.wessex.ac.uk/13 conferences/air-pollution-2013.html

Contact person: Rebecca Lawrence

Organized by: Wessex Institute of Technology

Sustainable Development Conference: Green technology, renewable energy and environmental protection

21st to 23rd June 2013

Venue : Bangkok, Thailand

Website: http://www.sdconference.org/

Contact person: Jovana Savic

Organized by: Tomorrow People Organization

International symposium on green technology - towards a sustainable future (ISGT2013)

10th to 11th July 2013

Venue : Bandar Sunway, Selangor, Malaysia

Website: http://www.eng.monash.edu.my/isgt2013/ Home.html

Contact person: Dr. Irene Chew Mei Leng

Organized by: School of Engineering

2013 4th International Conference on Environmental Engineering and Applications (ICEEA 2013)

24th to 25th August 2013

Venue: Singapore

Website: http://www.iceea.org/

Contact person: Mr. Lee

USEFUL WEBLINKS

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(Centre for Science and Environment)

www.epa.gov
(US Environmental Protection Agency)

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(ILO Encyclopaedia of Occupational Health & Safety)

www.cleanairworld.org
(National Association of Clean Air Agencies)

www.air-quality.org.uk
(An Environment Portal)