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ASSESSMENT OF AMBIENT AIR QUALITY IN CHIDAMBARAM A SOUTH INDIAN TOWN

P. BALASHANMUGAM*, A. R. RAMANATHAN, V. NEHRU KUMAR

Annamalai University, Annamalai Nagar,
Chidambaram, Cuddalore District, Tamilnadu, India
*Corresponding Author: pbsapme1980@gmail.com

Abstract

Worldwide preliminary studies in large number are advocated to create data base, to identify potential cities / towns that warrant "continuous ambient air quality monitoring and control mechanism" and to evolve priorities for clean air target. The results reported pertain to an eight hour random preliminary air sampling exercise carried out at each of the eight select locations in Chidambaram, a southern semi urban settlement in India. Criteria pollutants SPM, CO, SO_2 and NO_2 measured are found to have either crossed or on the verge of crossing the limits, necessitating the immediate installation of a continuous monitoring and control mechanism. While transport related emissions are the major sources of air contamination, increasing civil construction activities also contribute to particulates. The exponential rise in volume of vehicles, disadvantageous traffic flow pattern, differing driving cycle pattern and human interceptions deserve due attention. It is concluded that Chidambaram town is a strong case for continuous monitoring of ambient air quality due to alarming and increasing level of pollutants.

Keywords: Ambient air quality, Preliminary assessment, Transport emissions, Semi-urban air sampling, Criteria pollutant.

1. Introduction

Developed and developing economy and globalization have resulted in migration of fast changing energy intensive life style, mechanization and automation as a consequence of scientific advances and evolution of newer branches of science. Polluted air, polluted space, polluted land and polluted water are the undesired results. Awareness of air contamination and measures to monitor and control air quality are inadequate considering the rapidity of increase in pollution levels. Pragmatic ill effects on human health and difficulty in treating air warrant due attention to continuously assess, monitor and control the ambient air quality, air being a primary source of lives.

Ill effects of air pollutants on human health

Carbon monoxide causes dizziness, headache, fatigue, and impaired judgment. It affects the functioning of brain and heart. At higher concentration the impact is fatal. Particulate matter causes respiratory disorder, asthma, reduced atmosphere visibility and cancer. It affects lungs and tissues. Oxides of nitrogen cause lung irritation, bronchitis, pneumonia, asthma, respiratory infections, pulmonary edema, and emphysema. Sulfur dioxide affects human lungs, and respiratory system. It causes sulfurous smog, acid rain and reduced atmosphere visibility. Particulate matter combined with sulphur oxides is more detrimental than either of them separately. Ground level ozone in photochemical smog (smog is the product of reaction of CO, NOx and HC with each other in the presence of sunlight) causes chest constriction and irritation of the mucous membrane infection.

A carcinogen is any substance, radionuclide, or radiation that is an agent directly involved in causing cancer. This may be due to the ability to damage the genome or to the disruption of cellular metabolic processes. Several radioactive substances are considered carcinogens, but their carcinogenic activity is attributed to the radiation, for example gamma rays and alpha particles, which they emit. Common examples of carcinogens are inhaled asbestos, certain dioxins, and tobacco smoke. Cancer is a disease in which damaged cells do not undergo programmed cell death. Carcinogens may increase the risk of cancer by altering cellular metabolism or damaging DNA directly in cells, which interferes with biological processes, and induces the uncontrolled, malignant division, ultimately leading to the formation of tumors. Usually DNA damage, if too severe to repair, leads to programmed cell death, but if the programmed cell death pathway is damaged, then the cell cannot prevent itself from becoming a cancer cell. After the carcinogen enters the body, the body makes an attempt to eliminate it through a process called biotransformation. The purpose of these reactions is to make the carcinogen more water-soluble so that it can be removed from the body. But these reactions can also convert a less toxic carcinogen into a more toxic carcinogen.

Heavy metals occur, in atmosphere, basically in particulate form. Hence, the transfer of air borne particles to land or water surfaces by dry, wet and occult deposition1 constitutes the first stage of accumulation of atmospheric heavy metals. Dry deposition involves four distinct processes: gravitational settling, impaction, turbulent transfer and transfer by Brownian motion.

There are 35 metals that concern us because of occupational or residential exposure; 23 of these are the heavy elements or "heavy metals": antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc [1]. Interestingly, small amounts of these elements are common in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chronic toxicity (poisoning). Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. Long-term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that mimic Alzheimer's disease, Parkinson's disease, muscular dystrophy, and multiple sclerosis. Allergies are not uncommon and repeated long-term contact with some metals or their compounds may even cause cancer (International Occupational Safety and Health Information Centre) [2].

For some heavy metals, toxic levels can be just above the background concentrations naturally found in nature. Therefore, it is important for us to inform ourselves about the heavy metals and to take protective measures against excessive exposure. In most parts of the United States, heavy metal toxicity is an uncommon medical condition; however, it is a clinically significant condition when it does occur. If unrecognized or inappropriately treated, toxicity can result in significant illness and reduced quality of life [3]. For persons who suspect that they or someone in their household might have heavy metal toxicity, testing is essential. Appropriate conventional and natural medical procedures may need to be pursued [4].

Chidambaram a semi urban settlement

Chidambaram is an ancient southern town in the state of Tamilnadu, India. Popularly known as temple the head quarters for saivates (a major seat of worship for Hindus) is believed to be the heart for the world. The shrine depicts the space, one of the five forms of Shiva, others being land, air, water and fire. Space means that *material life is nothing* compared to spiritual. The presiding deity is Lord Nataraja (king of dance) and His cosmic dance of bliss is believed to spin all worldly actions. Annamalai University, a residential unitary seat of higher learning adjoining Chidambaram has more than 75 years of standing with variety of faculties. Population of Chidambaram town is around a lakh excluding that of tens of existing and emerging mini satellite townships.

2. Previous Work

Mahendra and Krishnamoothy [5] have reported overall improvement in environment at three locations of Bangalore city (India) with the introduction of one way in the traffic system. They attribute the reductions in CO, NO_2, SO_2 and SPM levels to consequent smooth and eased traffic flow, minimum stop-go driving and hence less frequent accelerations and decelerations of vehicles. Their data lack consistency. After the introduction of one way CO and SPM reductions were only marginal at two of the three sites sampled, and NO_2 reduction was marginal at one of the three sites. SPM and SO_2 showed to be on the increase at one each of the sites. Hence it is obvious as there are stake holders other than traffic flow, a detailed understanding and governing of all related features are called for. Such factors may include dynamics of traffic density, traffic signal type in vogue, vehicle driving cycles, auto fuel employed, air sampling period, rationalization of measured pollutant levels, variation in vehicle group participation with time, human interception, nature and duration of exposure.

Pankajam et al. [6] in their investigation have quantified the lung function impairment (volume and flow reduction) in shop keepers of Kottayam city in Kerala state of India, exposed occupationally to automobile exhaust. It is opined that similar investigations deserve extension to groups alike and human safety / clean air measures adopted. Gokhale et al. [7] have developed that the statistical distribution model fitting to carbon monoxide (CO) concentrations for the heterogeneous traffic pattern at the urban hotspots in Delhi, India. Three years of 1-h average CO concentration data (from 1997 to 1999), at the traffic intersection and near a roadway, are examined using goodness-of-fit tests for the suitable statistical distributional form. The results showed that the log logistic distribution model (LLD) best fit the CO concentration data at both the intersection and the roadway. It can therefore be deduced that 'heterogeneity in traffic' and 'emission patterns' may be affecting the statistical distributional form significantly. On the contrary, the fitting of the LND model on the CO concentration data show significant influence of traffic 'heterogeneity', 'emission pattern' and 'meteorology' on the CO concentrations. Further, the CO concentrations from vehicular exhausts in the near field follow LLD when the 'heterogeneous' traffic conditions exist. In addition, the LLD describes the 'extremes' i.e. the upper 'tail', more accurately, when compared to the LND.

Pulikesi et al. [8] have reported during the summer of 2005, concentrations of surface ozone (O3), oxides of nitrogen (NOx), respirrable suspended particulate matter (RSPM) and total suspended particulate matter (TSPM), relative humidity (RH), wind speed (WS) and wind direction (WD) were collected over successive periods of about 24 h at five sites. UV photometric ozone analyzer was used to measure the concentration of surface O3. The study deals with the characteristics of hourly and daily mean surface O3 under different climatic conditions, such as temperature, relative humidity, wind speed and wind direction and other pollutant concentrations. The maximum hourly O3 concentration reached 53 ppb on 17th May. The ground-level O3 concentration in Chennai varied between 2 and 53 ppb. The concentration of NOx and O3 were below the prescribed limits. The TSPM values were exceeded the National Ambient Air Quality Standards (NAAQS) at Koyambedu, Mandaveli, Taramani and Vallalar Nagar study area.

Srivastava et al. [9] have investigated that the potential particulate matter (PM) exposure, and the possible effective measures for interventions and assessment of sources in indoor environments, a pilot study was conducted at Jawaharlal Nehru University (JNU), New Delhi. The indoor particles were collected from 5th April to 26th June 2000, using a tapered element oscillating microbalance (TEOM). The particles were analyzed by gravimetry, atomic absorption spectrometry (AAS) and scanning electron microscopy (SEM) in order to investigate the mass concentration, physico-chemical properties and morphology of the particles. The gravimetric and AAS results confirmed that the suspended particulate matter (SPM) and metal concentrations were higher than the National Ambient Air Quality Standards (NAAQS) for Delhi. The maximum contributions of SPM were observed to be due to wind-blown crustal dust and vehicular pollution. The SEM analysis of particles showed the presence of a variety of particles, but confirmed the dominance of silicon and soot particles.

Simkhada et al. [10] have reported that the national ambient air quality standards prescribe levels of PM10 for a monitoring duration of 24 hours. However, in the present study, since the sampling was done on an average period of 8 hours to have an idea of pollutant levels, the levels have been compared to the prescribed standards with a premise that most of the pollution exist during the day time. The major air pollutants when measured at the six different locations along the Bishnumati corridor and analyzed revealed that the PM10 is a major problem. The respiratory health and the daily particulate matter concentration are positively correlated Concentrations of Particulate Matter however vary at different locations and seasonally (Murthy, 2004). Other gaseous pollutants are SO2 and NOx. Similarly, bacterial loads and fungal loads were also measured in six different sampling sites. Bacterial load and fungal load vary according to the nature of location and season. Concentrations of air micro flora also vary at different locations depending on the sanitations and waste management of the area. At present, Teku Dovan area is actually a landfill site under Kathmandu Metropolitan City Office for solid wastes and the area is characterized by road without asphalt.

3. Air Sampling and Chemical Analysis

An eight hour ambient air sampling has been carried out using a high volume sampler at eight different select pollution prone locations on a randomly selected day each during 06-03-2007 to 29-03-2007. Sampling was done at each location for continuous 3 days. Table 1 shows the location, monitoring period and classification of site for SPM, NO_2, So_2 and CO in the Chidambaram.

Table 1. Details of Air Quality Monitoring Station in Chidambaram, India.

Sampling site with land marks	Site classification	Monitoring period (10.00 am to 06.00 pm) Sampling duration 8 hours for SPM, SO_2 and NO_x and one hour for CO
Manned railway level crossing (Chidambarm-Annamalai nagar)	Traffic area	06-03-2007 to 08-03-2007
South - east junction (car street) (Near National shopping)	Traffic area	09-03-2007 to 11-03-2007
Sabanayagar and S.P.koil Street Junction(Near Pachayappas school)	Traffic area	12-03-2007 to 14-03-2007
Chidambaram bus stand	Traffic area	15-03-2007 to 17-03-2007
North - west junction (car street)	Traffic area	18-03-2007 to 20-03-2007
Sirkazhi main road (Srinivasa marriage hall	Traffic area	21-03-2007 to 23-03-2007
Omakulam (Near Mandakarai bus stop)	Traffic area	24-03-2007 to 26-03-2007
Srinivasa theatre junction (Near Doss Creation)	Traffic area	27-03-200729-03-2007

3.1. The selection of the sampling sites includes

(i) Manned railway level crossing between Chidambaram and Annamalai nagar

This site encountered gate closures, heavy traffic flow, stop-go opportunity and railway over bridge construction activities. Percentage traffic shares of two wheelers/ three wheelers/ light vehicles / heavy vehicles were 61.33, 21.70, 13.32 and 3.62 respectively.

(ii) South and East car street junction

This site has one way traffic system, heavy non-smooth vehicle flow, narrow sharp turn, shopping complex, and parking lots. Percentage traffic shares of two wheelers/ three wheelers/ light vehicles/ heavy vehicles were 53.76, 15.50, 13.98 and 16.78 respectively.

(iii) Sabanayagar and S. P. Koil street junction with signalized inter section.

This site has one way traffic system, vehicle queuing, stop-go practice, open-loop signal control, and high vehicle mobility. Percentage traffic shares of two wheelers/ three wheelers/ light vehicles/ heavy vehicles were 55.03, 16.35, 11.61 and 16.96 respectively.

(iv) Chidambaram bus terminus

This site faces large number of bus operations, vehicle queuing, frequent stop- go operation, idling, acceleration, cruising, deceleration, and non –smooth vehicle flow. Percentage traffic shares of two wheelers / three wheelers / light vehicles / heavy vehicles were 8.95, 0.46, 0.07 and 90.50 respectively.

(v) North and west car street junction with signalized inter section

This site has one way traffic system, less frequent queuing, less stop-go practice, and commercial bazaar activity. Percentage traffic shares of two wheelers/ three wheelers/ light vehicles / heavy vehicles were 62.5, 11.56, 9.15 and 16.68 respectively.

(vi) Sirkazhi main road (near Srinivasa marriage hall)

This site has one way traffic system, heavy traffic flow, non-smooth due to narrowing and abrupt turning of roads. Percentage traffic shares of two wheelers/ three wheelers/ light vehicles / heavy vehicles were 50.9, 18.72, 13.4 and 16.8 respectively.

(vii) Omakulam (near Mandakarai bus stop)

This site possesses one way traffic system, vehicle queuing and narrow sharp turn. Percentage traffic shares of two wheelers/ three wheelers/ light vehicles / heavy vehicles were 56.9, 16.6, 13.6 and 12.7 respectively.

(viii) Srinivasa theatre junction (near Doss creation)

This site has two way traffic system, Vehicle queuing and heavy traffic flow. Percentage traffic shares of two wheelers/ three wheelers/ light vehicles / heavy vehicles were 71.9, 11.6, 9.8 and 6.5 respectively.

3.2. The selection of the sampling sites

SPM (suspended particulate matter) concentrations were found by measuring the sample air volume (m^3) through an orifice meter and the mass (µg) of particulate matter collected in a Watt man grade 1 fiberglass filter paper.

Concentrations of SO_2 and NO_2 ($\mu g/m^3$ or PPM) were colorimetrically determined using a spectrophotometer. 5 to 20 ml of reagent (sodium tetra chloro mercurate for West and Geake method to find SO_2 and sodium hydroxide for NO_2) filled in a train of impingers of the high volume sampler trap specific contaminant in air. Air flows to the impingers were determined using rota meters. Instantaneous carbon monoxide concentrations were directly recorded using a battery operated portable CO monitor (CO 84 ENDEE make.)

4. Results and Discussion

Figures 1, 2 and Table 2 illustrate the eight hour contaminant levels at the sampled sites along with standard limits for comparison. SPM and NO_2 levels have exceeded limits at all the eight sample sites. CO level has crossed the limit at seven of the eight sample sites. SO_2 at all the eight sites has not crossed the limits. It is likely that the alarming levels of all the pollutants will be revealed if a continuous monitoring is carried out, in the place of random sampling.

There is considerable correlation between pollutant levels and activities at the sites. At bus terminus with intensive transport activities three pollutants are found to cross the limits (SPM by 38%, NO_2 by 19% and CO by 20%). SPM at the railway gate with two way traffic system is the highest (64% more than the limit) due to heavy automobile mobility and over bridge construction activity. NO_2 here is higher than the limit by 18%, and SO_2 is 57.2 percent of the limit.

Table 2. Result Tabulation.

Location	SPM +Deviation From standard Limit (200 μg/m^3)	Rank	NO_2 +Deviation From standard Limit (80 μg/m^3)	Rank	SO_2 Rank -Deviation From standard Limit (80μg/m^3)	Rank	CO +/-Deviation From standard Limit (2 mg/m^3)
Railway level crossing between Chidambaram and Annamalai nagar (**1**)	**327.92 (63.96%)**	**1**	**96 (20%)**	**1**	**45.76 (42.80%)**	**7**	**0-2.4 (20%)**
Sirkhazi main road (**6**)	**299.44 (49.72%)**	**2**	**88.29 (10.36%)**	**4**	**52.36 (34.55%)**	**2**	**0-2.4 (20%)**
South - west junction (car street) (**2**)	**299.31 (49.65%)**	**3**	**94.18 (17.7%)**	**3**	**48.03 (39.96%)**	**4**	**0-2.4 (20%)**
Bus stand (**4**)	**276.32 (38.16%)**	**4**	**95.43 (19.28%)**	**2**	**56.91 (28.2%)**	**1**	**0-2.4 (20%)**
S.p.koil and sabanayagar street junction (**3**)	**264.95 (32.47%)**	**5**	**85.58 (7.4%)**	**7**	**46.78 (41.53%)**	**6**	**0-2.4 (20%)**
North - west junction (car street) (**5**)	**253.66 (26.83%)**	**6**	**87.52 (9.4%)**	**5**	**39.46 (50.68%)**	**8**	**0-2.4 (20%)**
Omakulam (**7**)	**251.04 (25.52%)**	**7**	**82.61 (3.26%)**	**8**	**48.10 (39.85%)**	**3**	**0-1.2 (-40%)**
Srinivasa Theatre junction (**8**)	**232.52 (16.26%)**	**8**	**87.212 (9.01%)**	**6**	**47.44 (40.7%)**	**5**	**0-2.4 (20%)**

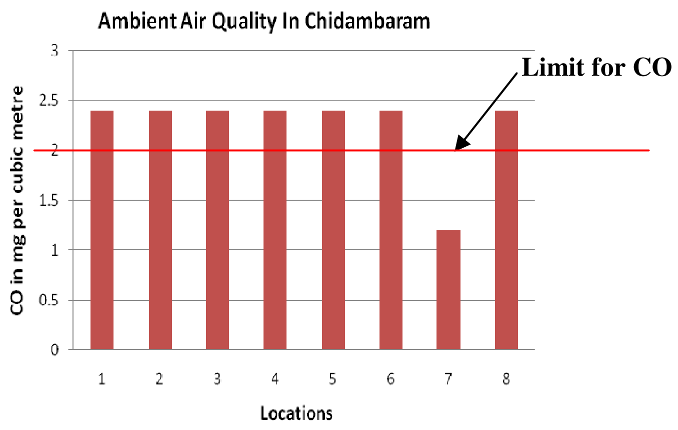

Fig. 1. Ambient Air Quality in Chidambaram.

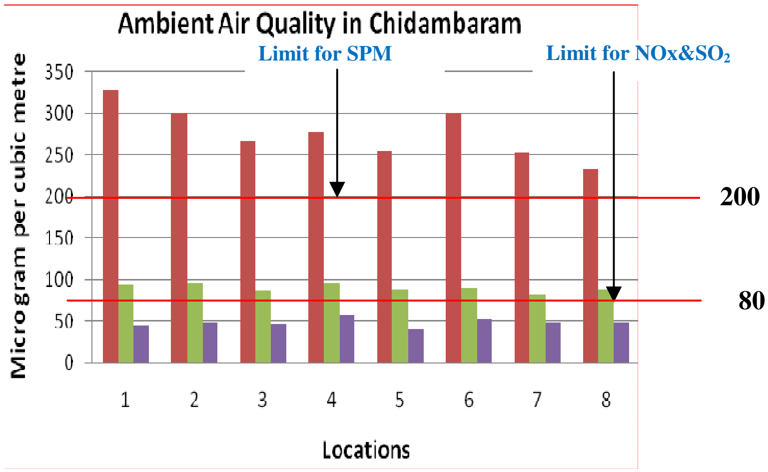

Fig. 2. Ambient Air Quality in Chidambaram.

1. Manned railway level crossing between Chidambaram and Annamalai nagar (06-03-2007 TO 08-03-2007)
2. South and east car street junction (09-03-2007 TO11-03-2007)
3. Sabanayagar and S.P.koil Street junction (12-03-2007 TO14-03-2007)
4. Chidambaram bus stand (15-03-2007 TO 17-03-2007)
5. North and west car street junction (18-03-2007 TO 20-03-2007)
6. Sirkazhi main road (Srinivasa marriage hall) (21-03-2007 TO 23-03-2007)
7. Omakulam (Near Mandakarai bus stop) (24-03-2007 TO 26-03-2007)
8. Srinivasa theatre junction (27-03-2007 TO 29-03-2007).

NO_2 level is the second largest at the railway level crossing. The only source for NO_2 is the auto emission, in the absence of any other industrial or commercial activities in the region.

At places with one way traffic system and location specific restricted automobile mobility, the pollutant levels are observed to be relatively lower. Carbon monoxide values across the sample sites vary from zero to 2.4 mg/m^3 against time. The variation is due to vehicular flow pattern, sensor proximity, and environment. The highest value recorded is *20 percent more than the standard limit* 2 mg/m^3.

Over all ranges of pollutant levels in Chidambaram town

The range of pollutant levels as per the preliminary random investigation carried out at 8 select locations in Chidambaram (see Fig. 3), a south Indian town are summarized in Table 3 below.

Table 3. The Range of Pollutant Levels in a South Indian Town.

Pollutant	Level (μg/m^3)	Standard limit (μg/m^3)
SPM	232.52 to 327.92	200
NO_2	82.61 to 96	80
SO_2	39.46 to 56.91	80
CO	0 to 2.4 (mg/m^3)	2 mg/m^3

The results of the investigations on ambient air quality in Chidambaram are on the anticipated lines, making a clear case warranting immediate installation of a "continuous ambient air quality monitoring process" on stream.

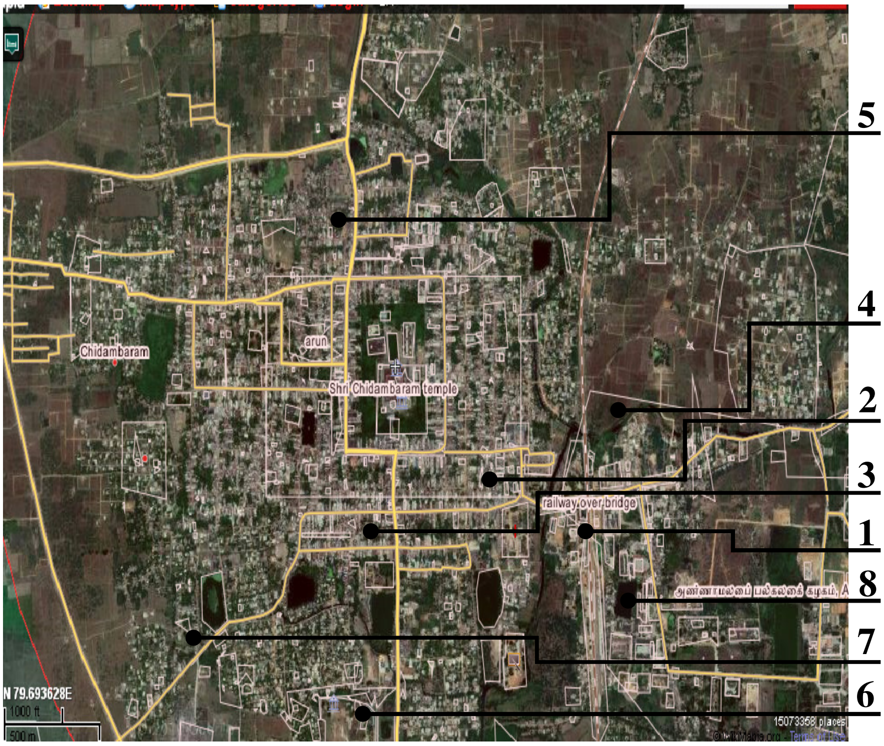

Fig. 3. Selected Locations of Chidambaram.

5. Conclusions

Some concluding observations from this investigation are given below

- Criteria pollutant levels of SPM, NO_2 and CO in the ambient air of Chidambaram town are found to cross the limits in the single day per site random sampling, while SO_2 level is also considerable at about 71%(maximum). It is likely that right now the levels of all the pollutants have crossed the limits at all the sites, but not revealed due to random nature of sampling. The alarming situation will worsen further in future due to rapid addition of two, three and four wheelers on the road.
- Preliminary random studies in all pollution prone towns / cities irrespective of the grade to quantify the pollutant levels will throw light on the range of pollutant level, cause-effect correlations, trend evaluation, remedial strategies and priorities for the installation of continuous pollution monitoring and control mechanism.
- Chidambaram town is a stronger case for continuous monitoring of ambient air quality.
- Traffic diversions, better traffic regulation, restricting vehicles with high emission features, staggering office/school timings, provision of alternate routes, by-pass infrastructures and encouraging other modes of transport worth considerations. Phasing out older vehicle versions, arranging for periodic vehicle maintenance, encouraging multimode transport system and strengthening of related researches are some of the remedies.
- Safety measures against poor ambient air quality are to be evolved and implemented. Priority locations (like bus stand, road junctions, and level crossings) and priority occupants like the drivers, traffic control personnel, road side vendors/shopkeepers and theatre employees are to be paid due to consideration and attention.
- Continuous monitoring shall include all the six criteria pollutants ground level ozone ($O_{3)}$, Carbon monoxide (CO), Sulfur dioxide (SO_2), Small particulates (PM_{10}), Nitrogen dioxide (NO_2), and the lead (Pb). Additionally CO_2 and volatile organic compounds like benzene the class “A” human carcinogen also need to be quantified.
- Global attempts to combat air pollution need to attract the support of institutions like World Health Organization, World Bank and United Nations Organization.

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References

1. Glanze, W.D. (1996). *Mosby medical encyclobidia*. Revised edition. St. Louis, MO: C.V. Mosby.

2. International Occupational Safety and Health Information Centre (1999). *Metals*. In basics of chemical safety, Chapter 7, 1999, Geneva: International Labour Organization.
3. Ferner, D.J. (2001). Toxicity, heavy metals. *eMed. Journal*, 2(5), 1.
4. Dupler, D. (2001). *Heavy metal poisoning*. Gale encyclopedia of alternative medicine. Farmington Hills, MI: Gale Group.
5. Mahendra, S.P.; and Krishnamurthy, D. (2005). Impact of introduction of one way traffic system on ambient air quality. *Pollution Research*, 24(1), 213-216.
6. Pankajam, K.N.; Kesavachandran, R.H.; Reethamma, C.; Shashidhar, K.V. (2005). Effects of automobile exhaust pollution on the pulmonary functions in shop keepers. *Pollution Research*, 24(1), 49-54.
7. Gokhale, S.; and Khare, M. (2006). Statistical behaviour of carbon monoxide from vehicular exhausts in urban environments. *Environmental Modelling & Software*, 22(4), 526-535.
8. Pulikesi, M.; Baskaraligam, P.; Elango, D.; Rayudu,V.N.; Ramamurthi, V.; and Sivanesan, S. (2006). Air quality monitoring in Chennai, India, in the Summer of 2005. *Journal of Hazardous Materials*, 136(3), 589-596.
9. Srivastava, A.; and Jain, V.K. (2006). A study to characterize the suspended particulate matter in an indoor environment in Delhi, India. *Building and Environment*, 42(5), 2046-2052.
10. Simkhada, K.; Murthy K.V.; and Khanal, S.N. (2005). Assessment of ambient air quality in Bishnumati corridor Kathmandu Metropolis. *International Journal of Environmental Science and Technology*, 2(3), 217-222.