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Assessment of Semi-Urban Air Pollution and Its Health Impacts Due to Vehicular Traffic Emissions in Chidambaram Town, Tamilnadu, India

Dr. P. Balashanmugam*[1], Dr. V. Nehrukumar[2], G. Balasubramanian[3]
[1,3]Mechanical Engineering, Annamalai University, Chidambaram, Tamilnadu, India
[2]Civil Engineering, Annamalai University, Chidambaram, Tamilnadu, India

ABSTRACT

Traffic congestion increases vehicle emissions and degrades ambient air quality, and recent studies have shown excess morbidity and mortality for drivers, commuters and individuals living near major roadways. Presently, our understanding of the air pollution impacts of congestion on the roads is very limited. This study demonstrates an approach to characterize the risks of traffic for on- and near-road populations. An incremental analysis, which expresses the change in health risks for small increases in traffic volume, showed non-linear effects. For a freeway, "U" shaped trends of incremental risks were predicted for on-road populations, and incremental risks are flat at low traffic volumes for near-road populations. For an arterial road, the incremental risks increased sharply for both on- and near-road populations as traffic increased. These patterns result from changes in emission factors, the NO_2–NOx relationship, the travel delay for the on-road population, and the extended duration of rush hour for the near-road population. This study suggests that the health risks from congestion are potentially significant, and that additional traffic can significantly increase risks, depending on the type of road and other factors. Further, evaluations of risk associated with congestion must consider travel time, the duration of rush-hour, congestion-specific emission estimates, and uncertainties.

Keywords: Air Pollution, Ambient Air Quality, AQI, Sox, Nox, SPM, Road Traffic

I. INTRODUCTION

Human activities have begun to affect the environment through the release of pollutants (known as greenhouse gases or global warming pollutants) that exacerbate the earth's natural greenhouse effect. The environmental costs of automobile emission are hard to measure and vary according to local conditions. **McCubbin and Delucchi (1996)** corroborated this fact, and stated that health cost as a result of automobile emission could be as high as ten times that of cars and small buses. In their studies, most of the health hazards are as a result of the increased mortality due to the presence of volatile organic compounds, NO_2 and SO_2 in the inhaled air. The rest of the hazards are due to minor illness from ozone (O_3), formed in the atmosphere from volatile organic compounds (VOCs) and NOx. **Salami, (2007)** noted that vehicular emission has become the most complicated environmental challenges. In effect, cities which rely on a large number of automobiles for the bulk of daily transportation, and offering few efficient public mass transportation modes, may suffer from effects of automobile emission. It should be noted that perfectly operating motor engines would produce only water (H_2O) and carbon dioxide (CO_2) in the process of fuel combustion. However, with the problems of imperfect engines, improper fuel grades, lack of regular maintenance, physical ageing of engines, intensive use of vehicles and misuse of lubricants (especially motor cycles), all these factors combine to produce a constraint on perfect fuel combustion. The ultimate effect is the emission of CO, Hydrocarbons (HCs), NO_2 and SO_2 from the exhaust system and engine parts of motor vehicles. With the importation of used vehicles into Nigeria, there are lots of hazardous effects including global implications of such effects. Used vehicles pollute the air with the emission of incomplete combustion of the old engines. These pollutants include: CO, NO_2, SO_2, benzpyrene, aldehydes, ketones, chlorinated organic compounds, ozonides and peroxides, carbon compounds containing nitrogen such as peracetyl nitrides. NO_2 will oxidize to HNO_3, and SO_2 will oxidize to H_2SO_4, which now falls as acid rain or mist or fog.

The constant increase in the number of vehicles in Chidambaram is likely to increase the proportion of harmful emissions. Moreover, the fuel composition makes it likely that the vehicles in use in Nigeria will release high levels of emission. Vehicle emissions are affected by fuel type, especially sulphur content. As sulphur content increases, the fuel efficiency decreases and emissions of sulphur oxides, particulate matter, and volatile organic compounds increase (**World Bank, 2003**). In the US, petrol has a standard of 15ppm of sulphur, and in the EU, it has a standard of 50ppm. The concentrations of sulphur in fuels in Nigeria most often range from 500-2,000ppm, with a maximum allowable sulphur level of 5,000ppm (**United Nation Environmental Protection, 2007**). Therefore, it can be expected that vehicles in Nigeria will release remarkably more pollution.

A number of human activities have the potential of inducing the environment. One of the most important of these activities is the increase in atmospheric carbon monoxide due to the burning of fossil fuels from automobile emission. This is closely followed by the depletion of the ozone layer. Attempt at deliberate weather modification, as well as, direct heat output from energy production in cities and industrial areas also contribute to environmental problems. The consequences of these environmental problems make it necessary to maintain a constant and careful surveillance in this regard. The combustion of oil and gasoline from automobile emission accounts for the most of the environmental pollutants. For instance, **Dosunmu, (1998**) observed that more than 80% of carbon monoxide and 40% of the nitrogen oxides and hydrocarbons come from burning gasoline and diesel fuels in cars and trucks. Cities with larger populations will exhibit higher traffic pollution potentials due to large ownership of vehicles and tonnage of fuel consumption. With a population estimated at One Hundred and Fifty Million (150) million in 2006 for Nigeria and Niger State with about Four Million (**CBN, 2000**), Nigeria stands as the most populous country in Africa. **Chidi (2009)** reported that Nigeria undoubtedly harbours the highest number of vehicles in the West Coast of Africa. The report revealed that more than seven million vehicles operate on Nigerian roads on a daily basis, with the regrets that the nation's roads have suffered gross negligence due to lack of maintenance thereby contributing to the stress vehicles experience on the road and contributing more emission than expected.

Air pollution is the introduction into the atmosphere of chemicals, particulates, or biological materials that cause discomfort, disease, or death to humans, damage other living organisms such as food crops, or damage the natural environment or environment. The atmosphere is a complex dynamic natural gaseous system that is essential to support life on planet Earth. Stratospheric ozone depletion due to air pollution has long been recognized as a threat to human health as well as to the Earth's ecosystems. Indoor air pollution and urban air quality are listed as two of the World's Worst Toxic Pollution Problems in the 2008 Blacksmith Institute World's Worst Polluted Places report. Air pollution, contamination of the air by noxious gases and minute particles of solid and liquid matter (particulates) in concentrations that endanger health. The major sources of air pollution are transportation engines, power and heat generation, industrial processes, and the burning of solid waste. The combustion of gasoline and other hydrocarbon fuels in automobiles, trucks, and jet airplanes produces several primary pollutants: nitrogen oxides, gaseous hydrocarbons, and carbon monoxide, as well as large quantities of particulates, chiefly lead. In the presence of sunlight, nitrogen oxides combine with hydrocarbons to form a secondary class of pollutants, the photochemical oxidants, among them ozone and the eye-stinging peroxyacetylnitrate (PAN). Nitrogen oxides also react with oxygen in the air to form nitrogen dioxide, a foul-smelling brown gas. In urban areas like Los Angeles where transportation is the main cause of air pollution, nitrogen dioxide tints the air, blending with other contaminants and the atmospheric water vapour to produce brown smog. Although the use of catalytic converters has reduced smog-producing compounds in motor vehicle exhaust emissions, studies have shown that in so doing the converters produce nitrous oxide, which contributes substantially to global warming.

II. PREVIOUS WORK

Das et al. (1998) reported NO_2, SO_2, and NO_2/SO_2 levels in Jaipur for the sampling time of two-hours in the evening peak traffic hours at 49-stations. At residential areas, NO_2 and SO_2 values varied between 4.61-332.89 $\mu g/m^3$ and 115.84-296.74 $\mu g/m^3$; at the commercial areas, between 1.07-974.44 $\mu g/m^3$ and 136.96-912.64 $\mu g/m^3$; and at the industrial areas, between 26.16-78.81-$\mu g/m^3$ and 141.44-262.02 $\mu g/m^3$

Alam et al. (1999) studied the ambient air quality at roadside in Dhaka city and estimated the Air Quality Index (AQI) at various locations of the city of which seventy percent were severely polluted and the rest of the location were highly polluted. This environmental condition had very serious implications on the health of the inhabitants of the city, particularly the commuters, causing eye and skin irritation, headache and breathing problems.

Rajasekhar et al. (1999) reported that the higher concentration of SPM exceeds the permissible limits; this may be attributed to automobile pollution. The major sources of SO_2 are combustion, metallurgical industries such as smelting and automobile exhaust.

Dayal et al. (2000) studied the ambient air quality for 10 congested areas in Bangalore city. Results indicate that the SPM values in six out of 10 congested areas were above the limit, while oxides of nitrogen and SO_2 were within the prescribed limit in all the areas. Air Quality Index (AQI) for all places were calculated and it was observed that in 1 out of the 10 places, the air was clean, in 4, it could be classified as light air pollution and the remaining 5 places, were moderately polluted.

Meenambai et al. (2000) evaluated the ambient air quality of Coimbatore city at ten important junctions and found that the level of SPM exceeds the ambient air quality standard of CPCB and SO_2 and NOx were well within the limits. This high SPM concentration may be due to Traffic congestion, increased human activities and high rise buildings, existing parallel to each other. The remedial measures suggested include banning old technology vehicles, upgrading 2 stroke engines to 4 stroke engines, the use of catalytic converters, planting more trees along the roadsides and proper traffic regulation.

Rouphail et al. (2001) studied the effects of traffic flow on real-time vehicle emissions. The vehicle emission rates were evaluated during each 'mode' of travel, namely acceleration, deceleration, cruise, and idle. The study revealed that the vehicular emissions were higher when the vehicles transited from idle to acceleration mode, while in idle mode, the emissions were relatively low. The study also found that vehicle emissions were approximately twice as much during control-delay than when not-in-delay. This has further confirmed that the switching between free-flow and congested flow accounts for all four driving modes leading to higher emissions.

Ramesh (2004) studied three different locations during the period of 1993-2000 at Pondicherry. The air quality index has been developed and seasonal variation of air quality was examined. This study revealed that air quality has got deteriorated due to rapid industrialization and vehicular exhaust and improved recently as a result of the new industrial policy and emphasis on control of vehicular emission.

Sastry MS et al. (2004) studied and assessed the air quality status for Hyderabad city. Monitoring was carried out at 11 locations during March 2003. These observations on air quality status and AQEI predicts that most of the localities in Hyderabad are experiencing the air pollution stress and the trend is likely to worsen in near future if proper control measures are not implemented.

III. HEALTH EFFECTS OF AIR POLLUTANTS FROM MOTOR VEHICLES

It has been known for a long time that many of the substances that are referred to as air pollutants produce human health effects at high levels of exposure. This has been well documented in case studies of a series of air pollution episodes in the mid-1900s, which showed dramatic effects on health, and in high dose toxicological studies in animals. Air pollution episodes in the Meuse Valley of Belgium in 1930, Donora in the United States of America in 1948 and London, England in 1952 were investigated in detail. In the 1952 London air pollution episode, it was estimated that 4,000 extra deaths occurred as a result of the high concentrations of sulphur dioxide and particulate matter (**Brimblecombe, 1987**). Emphasis on these severe episodes of air pollution may have distracted attention from the effects of long term exposure to air pollutants. Studies in London in the 1950s and 60s (**Waller, 1971**) showed that the self-reported state of health of a panel of patients suffering from chronic bronchitis varied with day-to-day levels of pollution. It was noted, however, using simple methods of analysis, that symptoms did not increase unless the concentrations of smoke (measured as "British Standard Smoke") and sulphur dioxide exceeded 250 and 500 µg m-3, respectively. It is likely that, had more searching methods of analysis been applied, the effects would have been seen at lower concentrations. This is an early illustration of a feature of the effects of air pollution - known as the 'threshold effect'. The threshold, for any pollutant is the concentration below which no effect is observed (and it is different for different substances, sometimes zero). Since the 1950s a great body of evidence has accumulated showing that air pollutants have a damaging effect on health. Two features of that body of work are the consistency of the results and that the effects occur at concentrations of air pollutants previously considered to be "safe". Emissions from motor vehicles that can produce health effects are the gas carbon monoxide, nitrogen oxides, volatile organic compounds, and sulphur dioxide, as well as solid particulate matter (now commonly referred to as particles). Additionally, other gases (such as ozone) and particles (sulphates and nitrates) can form in the atmosphere from reactions involving some of those primary emissions.

A. Carbon monoxide

B.

Carbon monoxide is an odourless gas formed as a result of incomplete combustion of carbon containing fuels, including petrol and diesel. Carbon monoxide is readily absorbed from the lungs into the blood stream, which then reacts with haemoglobin molecules in the blood to form carboxyhaemoglobin. This reduces the oxygen carrying capacity of blood, which in turn impairs oxygen release into tissue and adversely affects sensitive organs such as the brain and heart (**Bascom et al, 1996**). Motor vehicles are the predominant sources of carbon monoxide in most urban areas. As a consequence of the age of the vehicle fleet, New Zealand has relatively high urban air concentrations of carbon monoxide. It has been reported (**Ministry of Economic Development, 2001**) that nearly 50% of the New Zealand car fleet are more than 10 years old, and only one in five is less than five years old. Furthermore, only about one-quarter of the car fleet have catalytic converters, even though they have been mandatory in countries from where vehicles have been sourced since the 1970s.

B. Nitrogen dioxide

Nitrogen oxides (primarily nitric oxide and lesser quantities of nitrogen dioxide) are gases formed by oxidation of nitrogen in air at high combustion temperatures. Nitric oxide is oxidised to nitrogen dioxide in ambient air, which has a major role in atmospheric reactions that are associated with the formation of photochemical oxidants (such as ozone) and particles (such as nitrates). Nitrogen dioxide is also a serious air pollutant in its own right. It contributes both to morbidity and mortality, especially in susceptible groups such as young children, asthmatics, and those with chronic bronchitis and related conditions (for example, **Morris and Naumova, 1998**). Nitrogen dioxide appears to exert its effects directly on the lung, leading to an inflammatory reaction on the surfaces of the lung (**Streeton, 1997**). Motor vehicles are usually the major sources of nitrogen oxides in urban areas. Air quality guidelines/standards for nitrogen dioxide are set to minimise the occurrence of changes in lung function in susceptible groups. The lowest observed effect level in asthmatics for short-term exposures to nitrogen dioxide is about 400 µg m-3. Although less data are available, there is increasing evidence that longer-term exposure to about 80 µg m-3 during early and middle childhood can lead to the development of recurrent upper and lower respiratory tract symptoms.

C. Hydrocarbons

Volatile organic compounds are a range of hydrocarbons, the most important of which are benzene, toluene, and xylene, 1, 3-butadiene, polycyclic aromatic hydrocarbons (PAHs), formaldehyde and acetaldehyde. The potential health impacts of these include carcinogenic and non-carcinogenic effects. Benzene and PAHs are definitely carcinogenic, 1, 3-butadiene and formaldehyde are probably carcinogenic, and acetaldehyde is possibly carcinogenic and skin irritation. Heavier volatile organic compounds are also responsible for much of the odour associated with diesel exhaust emissions. Motor vehicles are the predominant sources of volatile organic compounds in urban areas. Benzene, toluene, xylene, and 1, 3-butadiene is all largely associated with petrol vehicle emissions. The first three results from the benzene and aromatics contents of petrol, and 1, 3- butadiene results from the olefins content. Evaporative emissions, as well as exhaust emissions, can also be significant, especially for benzene. Motor vehicles are major sources of formaldehyde and acetaldehyde. These carbonyls are very reactive and are important in atmospheric reactions, being products of most photochemical reactions. PAHs arise from the incomplete combustion of fuels, including diesel. Of the volatile organic compounds, the most important in the New Zealand context is benzene. The benzene content of petrol is high, often exceeding 4% by volume, especially for the "premium" grade, whereas many overseas countries restrict the benzene content to less than 1% by volume. Health effects data and guidelines/standards for hazardous air pollutants have been reported elsewhere (**Chiodo and Rolfe, 2000**), and include recommended air quality guidelines for benzene of 10 µg m-3 (now) and 3.6 µg m-3 (when the benzene content of petrol is reduced), both guidelines being annual average concentrations. The implied cancer risks (leukaemia) corresponding to those air concentrations are, respectively, 44-75 per million population and 16-27 per million population, based on World Health Organization unit risk factors for benzene.

D. Sulphur dioxide

Sulphur oxides (primarily sulphur dioxide and lesser quantities of sulphur trioxide) are gases formed by the oxidation of sulphur contaminants in fuel on combustion. Sulphur dioxide is a potent respiratory irritant, and has been associated with increased hospital admissions for respiratory and cardiovascular disease (Bascom et al, 1996), as well as mortality (**Katsouyanniet al, 1997**). Asthmatics are a particularly susceptible group. Although sulphur dioxide concentrations in New Zealand are relatively low, and motor vehicles are minor contributors to ambient sulphur dioxide, the measured levels in Auckland (for example) have increased in recent years, after many years of decline, as a result of the increasing number of diesel vehicles (and the relatively high sulphur content of diesel in New Zealand). There appears to be a threshold concentration for adverse effects in asthmatics from short-term exposures to sulphur dioxide at a concentration of 570 µg m-3, for 15 minutes (**Streeton, 1997)**. Ambient air guidelines/standards are based on this figure, for example the guidelines for New Zealand are 350 µg m-3, 1-hour average, and 120 µg m-3, 24-hour average. Sulphur oxides from fuel combustion are further oxidised to solid sulphates, to a certain extent within the engine and completely in the atmosphere. The former inhibits the performance of exhaust emission control equipment for nitrogen oxides and particles, and this is a major reason why the sulphur contents of petrol and diesel are being reduced internationally.

E. Particulates

Fine particles such as sulphates cause increased morbidity and mortality, and there are no apparent threshold concentrations for those health effects. As a result the World Health Organization (WHO) has decided not to recommend air quality guidelines for particles, but most countries (including New Zealand) have been more pragmatic and have set guidelines (typically 50 µg m-3 for PM10, 24-hour average) aimed at minimising the occurrence of health effects. Recent preliminary research is showing that it is probably the finer particles causing greater effects (PM2.5), and particles from diesel emissions possibly having greater effects than those from other sources.

F. Ozone

Ozone is a secondary air pollutant formed by reactions of nitrogen oxides and volatile organic compounds in the presence of sunlight. These primary emissions arise mainly from motor vehicles. Ozone is only one of a group of chemicals called photochemical oxidants (commonly called photochemical smog), but it is the predominant one. Also present in photochemical smog are formaldehyde, other aldehydes, and peroxyacetyl nitrate. Ozone is another air pollutant that has respiratory tract impacts. Its toxicity occurs in a continuum in which higher concentrations, longer exposure, and greater activity levels during exposure cause greater effects. It contributes both to morbidity and mortality, especially in susceptible groups such as those with asthma and chronic lung disease, healthy young adults undertaking active outdoor exercise over extended periods, and the elderly, especially those with cardiovascular disease. Substantial acute effects occur during exercise with one hour exposures to ozone concentrations of 500 μg m-3 or higher. Ozone, like particles, is an air pollutant for which there is no indication of a threshold concentration for health effects (**Streeton, 1997**).

G. Major primary pollutants produced by human activity include

Sulphur oxides (SOx) - especially sulphur dioxide, a chemical compound with the formula SO_2. SO_2 is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulphur compounds, their combustion generates sulphur dioxide. Further oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.

Nitrogen oxides (NOx) - especially nitrogen dioxide are emitted from high temperature combustion, and are also produced naturally during thunderstorms by electric discharge can be seen as the brown haze dome above or plume downwind of cities. Nitrogen dioxide is the chemical compound with the formula NO_2. It is one of the several nitrogen oxides. This reddish-brown toxic gas has a characteristic sharp, biting odour. NO_2 is one of the most prominent air pollutants.

Carbon monoxide (CO) - is a colourless, odourless, non-irritating but very poisonous gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.

H.Health effects

Air pollution is a significant risk factor for multiple health conditions including respiratory infections, heart disease, and lung cancer, according to the WHO. The health effects caused by air pollution may include difficulty in breathing, wheezing, coughing and aggravation of existing respiratory and cardiac conditions. These effects can result in increased medication use, increased doctor or emergency room visits, more hospital admissions and premature death. The human health effects of poor air quality are far reaching but principally affect the body's respiratory system and the cardiovascular system. Individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, the individual's health status and genetics. The most common sources of air pollution include particulates, ozone, nitrogen dioxide, and sulphur dioxide. Both indoor and outdoor air pollution have caused approximately 3.3 million deaths worldwide. Children aged less than five years that live in developing countries are the most vulnerable population in terms of total deaths attributable to indoor and outdoor air pollution. The World Health Organization states that 2.4 million people die each year from causes directly attributable to air pollution, with 1.5 million of these deaths attributable to indoor air pollution. "Epidemiological studies suggest that more than 500,000 Americans die each year from cardiopulmonary disease linked to breathing fine particle air pollution. . ." A study by the University of Birmingham has shown a strong correlation between pneumonia related deaths and air pollution from motor vehicles. Worldwide more deaths per year are linked to air pollution than to automobile accidents. A 2005 study by the European Commission calculated that air pollution reduces life expectancy by an average of almost nine months across the European Union. Causes of deaths include aggravated asthma, emphysema, lung and heart diseases, and respiratory allergies. The US EPA estimates that a proposed set of changes in diesel engine technology could result in 12,000 less premature mortality, 15,000 fewer heart attacks, 6,000 fewer emergency room visits by children with asthma, and 8,900 fewer respiratory-related hospital admissions each year in the United States.

The US EPA estimates allowing a ground-level ozone concentration of 65 parts per billion would avert 1,700 to 5,100 premature deaths nationwide in 2020 compared with the current 75-ppb standard. The agency projects the stricter standard would also prevent an additional 26,000 cases of aggravated asthma and more than a million cases of missed work or school. The worst short term civilian pollution crisis in India was the 1984 Bhopal Disaster. Leaked industrial vapours from the Union Carbide factory, belonging to Union Carbide, Inc., U.S.A., killed more than 25,000 people outright and injured anywhere from 150,000 to 600,000. The United Kingdom suffered its worst air pollution event when the December 4 Great Smog of 1952 formed over London. In six days more than 4,000 died, and 8,000 more died within the following months. An accidental leak of anthrax spores from a biological warfare laboratory in the former USSR in 1979 near Sverdlovsk is believed to have been the cause of hundreds of civilian deaths. The worst single incident of air pollution to occur in the US occurred in Donora, Pennsylvania in late October, 1948, when 20 people died and over 7,000 were injured.

Diesel exhaust (DE) is a major contributor to combustion derived particulate matter air pollution. In several human experimental studies, using a well validated exposure chamber setup, DE has been linked to acute vascular dysfunction and increased thrombus formation. This serves as a plausible mechanistic link between the previously described association between particulates air pollution and increased cardiovascular morbidity and mortality.

I. Effects on cardiovascular health

A 2007 review of evidence found ambient air pollution exposure is a risk factor correlating with increased total mortality from cardiovascular events (range: 12% to 14% per a 10 microg/m^3 increase). Air pollution is also emerging as a risk factor for stroke, particularly in developing countries where pollutant levels are highest. A 2007 study found that in women air pollution is associated not with hemorrhagic but with ischemic stroke. Air pollution was also found to be associated with increased incidence and mortality from coronary stroke in a cohort study in 2011.

IV. METHODS AND MATERIAL

A. Site Description

Chidambaram is a town and a municipality in Cuddalore district in the Indian state of Tamil Nadu. It is the taluk headquarters of the Chidambaram taluk. The town is believed to be of significant antiquity and has been ruled, at different times, by the Medieval Cholas, Later Cholas, Later Pandyas, Vijayanagar Empire, Marathas and the British. The town is known for the Thillai Nataraja Temple, and the annual chariot festival held in the month of April. Chidambaram covers an area of 4.8 km^2 (1.9 sq mi) and had a population of 62,153 as of 2011. It is administered by a first-grade municipality. Teritiary sector involving tourism is the major occupation. Roadways are the major means of transportation with a total of 64.12 km (39.84 mi) of district roads, including one national highway passing through the town. As of 2011, there were eleven government schools: six primary schools, three middle schools and two higher secondary schools in Chidambaram. Annamalai University, established in 1929 in Chidambaram, is one of the oldest and most prominent universities in the state.

B. Monitoring of Pollutants

Four sampling stations were considered in the Chidambaram town as shown in the Figure 1 and sampling was carried for 3 days in each sampling station to determine the concentration of air pollutants such as SPM, SO_2 and NO_2 for 8 hours using instrument High Volume Air Sampler (HVAS).The instrument HVAS works on the principle that Stoke's law, offers basic approach to collection of SPM using this technique. When operated in virtually quiescent of air, the geometry of HVAS employs the sloping roof of the shelter as a means for causing air entering the sampler under the caves of the roof to change the direction by at least 900 before entering the horizontal filter. Only suspended particulate matter are collected on the filter paper. To determine the concentration of gaseous pollutants, 35mL of absorbing solution is taken in impinger and the gaseous pollutants are collected through bubbling of air into the absorbing solution and the concentration of gaseous pollutants are determined.

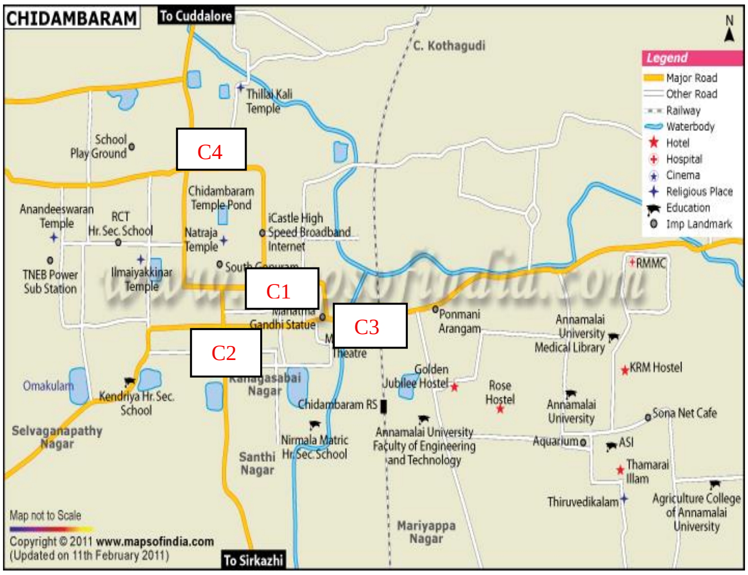

Figure 1 : The selection of sampling sites in Chidambaram

V. RESULTS AND DISCUSSION

A continuous investigation to evaluate the pollutant levels of SPM, SO_2, NOx and CO in ambient air of Chidambaram town has been carried out. Four different select pollution prone locations were intentionally identified and 8 hour sampling on 3days a month per each location were carried out during January to December 2008.The sampling site selected in Chidambaram is shown in table I.

TABLE I.
THE SAMPLING SITE SELECTED IN CHIDAMBARAM

Sampling site	Sampling site/code	Site Description
South car and east car street junction	C1	High traffic density and moderately populated
Sabanayagar and S.P.koil street junction	C2	High traffic density and thickly populated
Chidambaram bus stand	C3	High traffic density and thickly populated
North car and west car street junction	C4	High traffic density and low populated

A. Suspended Particulate Matter (SPM)

The yearly mean value of suspended particulate matter (SPM) at the four locations were , 274.676 µg/m^3, 267.209 µg/m^3, 289.89 µg/m^3 and 269.89 µg/m^3 respectively as shown in Figure 2. The highest SPM level at C3 (Chidambaram bus terminus) was due to large number of bus operations, vehicle queuing, frequent stop- go operation, idling, acceleration, cruising, deceleration, and non -smooth vehicle flow and second highest in south car and east car street junction may be due to the result of increased vehicular traffic in the area ,large number of privately owned motor vehicles, adulterated fuel supply, vehicles of obsolete two stroke technologies, road congestion, poor public transit system and bad maintenance Suspended particulate matter (SPM) was found to be highest at Chidambaram bus terminus. The level of SPM was observed above the safety limit at all the four sites in Chidambaram. The reason for high particulate matter levels may be vehicles, resuspension of traffic, dust, commercial and domestic use of fuels. Over the years there has been a dramatic increase in the number of vehicles, particularly the two wheelers that are added to the already burgeoning vehicular population.

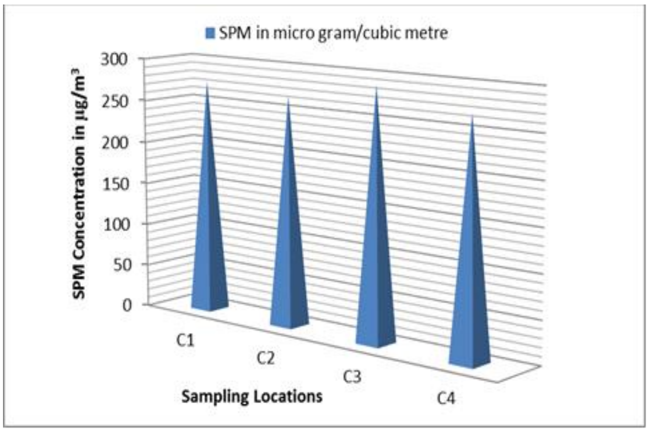

Figure 2 : Yearly mean Concentration (µg/m^3) of SPM at different sites of Chidambaram town

B. Sulphur dioxide (SO_2)

The yearly mean values of SO_2 at South and East car street junction, sabanayagar and S. P. Koil street junction, Chidambaram bus terminus and North car and west car street junctions were 42.96µg/m^3, 42.83 µg/m^3, 39.27 µg/m^3 and 46.34µg/m^3 respectively as shown in Figure 3. The average level of SO_2 was below the permissible limit (80 µg/m^3) as prescribed by NAAQS at all the four sites.SO_2 was found to be maximum in summer season at north car and west car street junction.

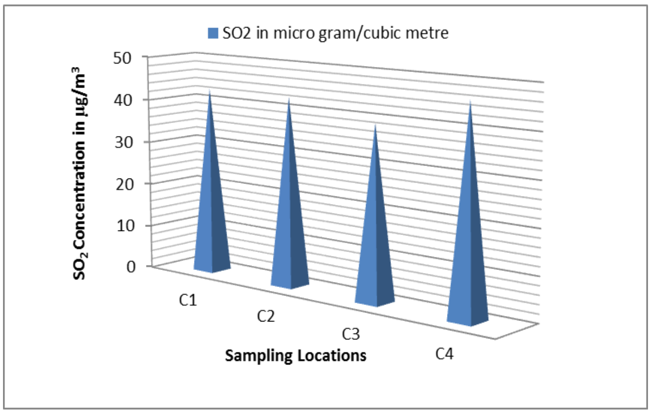

Figure 3 : Yearly mean Concentration (µg/m^3) of SO_2 at different sites of Chidambaram town

C. Oxides of Nitrogen (NO_X)

The yearly mean value of NOx at the four locations were 83.055 µg/m^3, 94.16 µg/m^3, 96.009 µg/m^3 and 91.88 µg/m^3 respectively as shown in Figure 4. Yearly mean of NO_X level exceeds the prescribed NAAQS (80 µg/m^3) limit at all the four sites. The highest oxides of nitrogen level at Chidambaram town were in C3, (Chidambaram bus terminus). This may be due to a large number of bus operations, vehicle queuing, frequent stop- go operation, idling, acceleration, cruising, deceleration, and non - smooth vehicle flow. The second highest level is in sabanayagar and S.P.koil Street junction. Old vehicles plying in the town are a major source of air pollution. This road is busy for almost 24 hours. The heavy vehicular traffic is the main attribute at Chidambaram town for the maximum level of oxides of nitrogen. The two wheelers dominate the total number of vehicles.

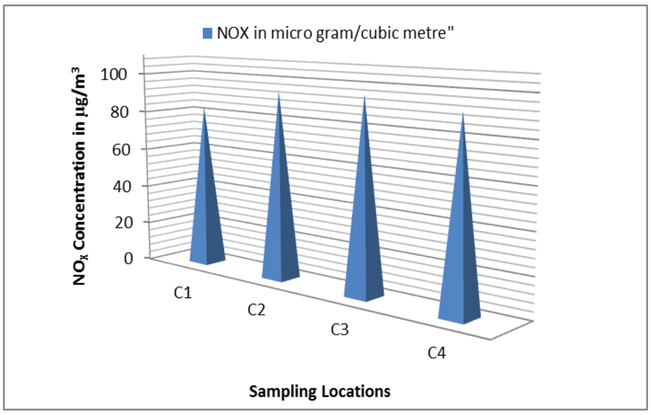

Figure: 4 Yearly mean Concentration (µg/m^3) of NO_X at different sites of Chidambaram town

D. Carbon monoxide (CO)

The yearly mean value of CO at the four locations were, 2.211 mg/m^3, 2.272 mg/m^3, 2.269 mg/m^3 and 2.281 mg/m^3 respectively as shown in Figure 5. The highest CO level at Chidambaram town was in C4, North car and west car street junction due to the petrol-driven vehicle, powered by 2-stroke engines. These are the sources of emission of carbon monoxide. Presently, 2-wheelers account for significant quantum of emission of the hydrocarbons and carbon monoxide. As these emissions are invisible, the general public is not aware of the role of 2-wheelers in the deteriorating air quality.

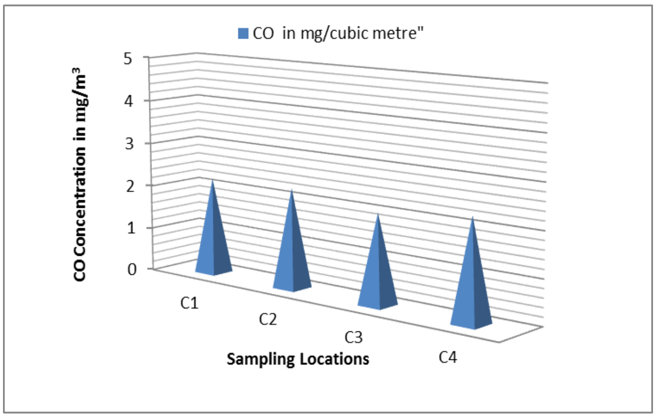

Figure: 5 Yearly mean Concentration (µg/m^3) of CO at different sites of Chidambaram town

VI. CONCLUSION

Many of the problems discussed earlier start at the local level. For quite a long time, scientists were under the impression that these problems were localized and they were trying out technologies and scientific methods to abate pollution and protect the local environment. But deep studies indicate that these problems not only affect the local environment, but the ill-effects spread to the other parts of the world as well. If this situation continues, then life on earth on becomes intolerable. Hence “Save our Earth” has become the slogan now. The problems and their ill-effects have to be thoroughly analysed at the global level. But, to prevent ill-effects, suitable action has to be taken at the level. Environment is a partner for development and not an impediment. In order to maintain essential ecological process, to ensure genetic diversity, sustain species and eco-systems, prevent environmental degradation, the following changes should be made in the vehicle to reduce the emission.

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