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Analysis Of Highway Air Pollution

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ABSTRACT

The traffic is growing at rapid rate in urban areas of India and the management of traffic operations on the limited road network of the cities has become a gigantic task to the concerned authorities. Despite the concerted efforts of concerned authorities aimed at augmenting road infrastructure, traffic congestion is continuing to increase leading to environmental degradation. Eventually, a major study was commissioned by the Government of India to quantify urban travel by road and associated air pollutants coming from automobile exhausts in eight cities namely, Delhi, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Kanpur and Agra. The main objective was to make an accurate assessment of total number of vehicles and develop database and techniques to estimate road traffic and pollution loads in each city. This paper describes operating characteristics of traffic and quantification of traffic and air pollution loads (base and horizon year) on major road network of Chennai city. Comparatively urbanization is moderate in India. This is because the major contributor to the Indian economy is agriculture and it is rural based. As per the Census of India 2001, the urban population of India is around 28 percent of the total population. This proportion of urban population has grown from ten percent in 1901 to twenty eight percent in 2001. The disturbing aspect of the urbanization trends in India is the skewed distribution of the urban population. Nearly seventy percent of the urban population is located in Class-I cities (i.e. population of 100 Thousand and above). Further, 38 percent of the total urban population is located in metropolitan cities (i.e. population of 1 million and above) numbering about thirty-five. This heavy concentration of population in a few centers has resulted in the expansion of cities in density as well as area.

KEYWORDS: Cauvery Irrigation System, cropping intensity, Hydrologic analysis, Irrigation systems in Tamilnadu .crop yield.

I. INTRODUCTION

Transport is a vital part of modern life. The freedom to travel short and long distances opens the horizons for personal development and professional activities, increases the options for leisure and holidays, and allows better contact and understanding between people. The economic development of entire regions depends on the easy access to people and goods ensured by contemporary transport technology. Owing to its flexibility, road transport is a major transport mode, and cars are objects of desire and pride in many societies.

Unfortunately, these positive aspects are closely associated with the hazards to the environment and human health caused by transport, particularly road transport. One of the leading concerns is the adverse effect on health of air pollution emitted by transport. Research in recent decades consistently indicates that outdoor air pollution harms health, and the evidence points to air pollution that stems from transport as an important contributor.

The present trend towards increasing transport volume, and the associated risk of harm to air quality and health, threaten the policy objective of many countries, also stated by the European Union (EU) in its 6th Environment Action Programme: to achieve pollution levels that do not give rise to harmful effects on human health and the environment (European Commission, 2001). A multitude of air contaminants of varying toxicity comes from road transport.

These contaminants originate from the tailpipes of vehicles with internal combustion engines, from other vehicle components (such as brake and clutch linings and pads, tyres and fuel tanks), and from road-surface wear and treatment materials. Road traffic can be labelled the most important source for some pollutants of great concern, such as nitrogen oxides, benzene and carbon monoxide. Until recently, leaded petrol was an important contributor to exposing the population to lead.

Recently, emissions of particulate matter (PM) have attracted much attention, owing mainly to epidemiological fi ndings that suggest that it is a major risk to human health. Besides the pollution sources already mentioned, PM is also formed in the atmosphere, as a secondary pollutant from gases such as nitrogen oxides, sulfur dioxide and volatile organic compounds (VOCs).

The pattern of population exposure depends on both pollution levels and population activities. Both the short-term pattern and long-term average of exposure, along with individual susceptibility, lead to adverse effects on health, which may occur either immediately or years later. Understanding the complex chain of events – from transport demand and traffic activities to emissions, ambient air quality, exposure and effects – requires information from a variety of scientific disciplines, often involving research on complex relationships.

As road transport is one of the sectors showing most rapid growth, and it is particularly important to pay proper attention to the pollution problems of vehicle exhaust gases. These emissions include some that are known to be toxic when absorbed into the body at high concentrations.

Increasing amounts of potentially harmful gases and particles are being emitted into the atmosphere on a global scale, resulting in damage to human health and the environment. It is damaging the resources needed for the long-term development of the planet. Hence, it is needed to develop echo friendly systems by controlling the exhausts that causes harm to environment.

II. NEED FOR THE STUDY

Evaluation of air quality levels due to road traffic has been found to be difficult, because the emission and dispersion of pollutants depends on many factors like traffic volume, traffic speed and composition of traffic, wind speed, the atmospheric conditions, the acceleration and deceleration of vehicles etc. This study is an attempt to model the air pollutants as a function of traffic and roadway parameters.

III. OBJECTIVES OF THE STUDY

The objectives of the study are:

- To determine the ambient air pollution due to CO, HC, NO_X, SO_2 and SPM at selected locations through field studies.
- To compare the measured carbon monoxide concentration values with those predicted using the CALINE 4 model.
- To study the statistical relationship between the predicted and observed values of carbon monoxide concentrations.

IV. DEFINITION OF AIR POLLUTION

Various authorities defined air pollution in different ways. According to the Bureau of Indian standards (BIS) (IS-4167, 1966) air pollution is the “Presence in ambient atmospheres of substances generally resulting from the activity of man, in sufficient concentration, present for a sufficient time and under circumstances such as to interfere with comfort, health or welfare of persons or with reasonable use or enjoyment of property.”

Thus, if the concentration of any substance or element in air is more than a certain volume, it may affect man and his property, directly or indirectly and may be termed as air pollution.

4.1 SOURCES OF AIR POLLUTION

A significant source of urban air pollution is the combustion of fuels by vehicle engines. Petrol and diesel-engined motor vehicles emit a wide variety of pollutants, principally carbon monoxide (CO), oxides of nitrogen (NO_X), volatile organic compounds (VOCs) and particulates (SPM), which have an increasing impact on urban air quality.

Classification I

Usually they are divided into two categories of primary sources and secondary sources.

a. Primary Sources:

Primary sources also called as natural sources. Natural process such as forest fires, decaying vegetation dust storms, and volcanic eruptions result in air pollution.

Primary pollutants are those that are emitted directly from the sources. Pollutants included under this category are particulate matter such as ash, smoke, dust, fumes, mist and spray; Inorganic gases such as sulphur dioxide, hydrogen sulphide, nitric oxide, carbon monoxide, carbon dioxide and hydrocarbons.

b. Secondary Sources:

Secondary sources also called as anthropogenic sources. Anthropogenic sources cover a wide spectrum of types. Table 1.1 includes a list of major anthrogenic air pollution sources, and their characteristic emissions.

Basically these are formed from chemical and photochemical reactions in the atmosphere. The reaction mechanisms and various steps involved in the process are influenced by many factors such as concentration of reactants, the amount of moisture present in the atmosphere, meteorological forces and local topography.

Classification II

Based on pattern of entry of pollutants in to the atmosphere they are classified into point source, line source, and area/volume source.

a. Line Sources:

Line sources reflect the contribution of mobile sources of pollutants. The predominant line sources are road traffic, although aircraft, shipping and railways can in certain circumstances represent significant line sources.

b. Point Sources:

Point sources are composed of industrial sources, the processes of which are regulated by the Environment Agency and local authorities respectively.

c. Area Sources:

Other Sources, which may singly have relatively small contribution, still warrant inclusion because collectively they are significant. Such sources include emissions from domestic central heating or contributions from smaller roads.

Sources of Auto Emissions

Emissions from automobiles are broadly classified into three categories

a. Exhaust emissions:

A significant proportion of the hydrocarbons come from the fuel tank, the carburetor and the crankcase, but the exhaust gases are the major source of pollutants. In addition to these air-borne pollutants there is a quantity of dust produced from the gradual wearing away of the rubber tyres, brake linings, and clutch plates of the vehicle.

Except for lead, which is confined to petrol, petrol engines and diesel engines produce similar materials in their exhausts, although the relative proportions are very different. The emission rates also vary considerably with the operating mode; i.e., idling, accelerating, cruising, or decelerating.

b. Crank case emissions:

About 20% of total HC occurs through blow by gases from crank case emissions. Emissions of HC from crank case of automobiles can be largely eliminated by the positive crank case ventilation (PCV) system. This system recycles crank case ventilation air and blow by gases to the engine intake instead of venting them to the atmosphere.

c. Evaporative emissions:

These emissions contain only hydrocarbons. These are due to evaporation from fuel tank and carburetor. It contributes to about 15% of total hydrocarbons. Evaporative emissions can be eliminated by storing fuel vaporous in crankcase, which absorbs HC for recycling to the engine.

4.2 EFFECTS OF AIR POLLUTION

Pollutants and Their Health Effects

Petrol and diesel engined motor vehicles emit a wide variety of pollutants, principally carbon monoxide (CO), oxides of nitrogen (NO_X), volatile organic compounds (VOCs) and particulate matter (PM_{10}), which have an increasing impact on urban air quality.

a. Sulphur dioxide:

The most important oxide emitted by pollution sources is sulphur dioxide (SO_2). Sulphur dioxide is a colourless gas with a characteristic, sharp, pungent odour. It is an acidic gas which combines with water vapour in the atmosphere to produce acid rain. These gases are formed when fossil fuels containing sulphur are burned.

Health Effects:

Even moderate concentrations may result in a fall in lung function in asthmatics. Tightness in the chest and coughing occur at high levels, and lung function of asthmatics may be impaired to the extent that medical help is required. Sulphur dioxide pollution is considered more harmful when particulate and other pollution concentrations are high.

b. Carbon monoxide:

It constitutes the single largest pollutant in the urban atmosphere. CO is colourless, odourless, and tasteless and has a boiling point of -192^{0}C. It is a toxic gas, which is emitted into the atmosphere as a result of combustion processes, and is also formed by the oxidation of hydrocarbons and other organic compounds. It has a strong affinity towards the hemoglobin of the bloodstream and is a dangerous asphyxiates.

Health Effects:

This gas prevents the normal transport of oxygen by the blood. This can lead to a significant reduction in the supply of oxygen to the heart, particularly in people suffering from heart disease.

c. Oxides of Nitrogen:

Nitrogen oxides are formed during high temperature combustion processes from the oxidation of nitrogen in the air or fuel. The principal source of nitrogen oxides - nitric oxide (NO) and nitrogen dioxide (NO_2), collectively known as NO_x is road traffic. NO and NO_2 concentrations are therefore greatest in urban areas where traffic is heaviest. Other important sources are power stations, heating plants and industrial processes.

Health Effects:

Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infections such as influenza. It is continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children.

d. Hydrocarbons:

The gaseous and volatile liquid hydrocarbons are of particular interest as air pollutants. Hydrocarbons can be saturated or unsaturated, branched or straight-chain, or can have a ring structure. The hydrocarbons in the air by themselves alone cause no harmful effects. They are of concern because the hydrocarbons undergo chemical reactions in the presence of sunlight and nitrogen oxides forming photochemical oxidants of which the predominant one is ozone.

e. Lead:

Particulate lead in air results from activities such as fossil fuel combustion (including vehicles), metal processing industries and waste incineration. As tetraethyl lead, it has been used for many years as an additive in petrol; most airborne emissions of lead in Europe therefore originate from petrol-engine motor vehicles. With the increasing use of unleaded petrol, however, emissions and concentrations in air have declined steadily in recent years.

Health Effects:

Even small amounts of lead can be harmful, especially to infants and young children. Exposure has also been linked to impaired mental function, visual-motor performance and neurological damage in children, and memory and attention span.

f. Particulate Matter:

In general the term 'particulate' refers to all atmospheric substances that are not gases. They can be suspended droplets or solid particles or mixtures of the two. Airborne particulate matter varies widely in its physical and chemical composition, source and particle size.

Particulates may be classified as Dust, Smoke, Fumes, Mist, Fog, and Aerosol. PM10 particles (the fraction of particulates in air of very small size (<10 μm)) are of major current concern, as they are small enough to penetrate deep into the lungs and so potentially pose significant health risks. The principal source of airborne PM10 matter in European cities is road traffic emissions, particularly from diesel vehicles.

Health effects:

Fine particles can be carried deep into the lungs where they can cause inflammation and a worsening of the condition of people with heart and lung diseases. In addition, they may carry surface-absorbed carcinogenic compounds into the lungs.

g. Ozone:

Ground-level ozone (O_3), unlike other pollutants mentioned, is not emitted directly into the atmosphere, but is a secondary pollutant produced by reaction between nitrogen dioxide (NO_2), hydrocarbons and sunlight. Ozone levels are not as high in urban areas (where high levels of NO are emitted from vehicles) as in rural areas.

Sunlight provides the energy to initiate ozone formation; consequently, high levels of ozone are generally observed during hot, still sunny, summertime weather.

Health effects:

Ozone irritates the airways of the lungs, increasing the symptoms of those suffering from asthma and lung diseases.

h. Volatile Organic Compounds (VOCs):

VOCs are released in vehicle exhaust gases either as unburned fuels or as combustion products, and are also emitted by the evaporation of solvents and motor fuels.

Benzene is a VOC, which is a minor constituent of petrol. The main sources of benzene in the atmosphere in Europe are the distribution and combustion of petrol. Of these, combustion by petrol vehicles is the single biggest source (70% of total emissions). **1,3-butadiene**, like benzene, is a VOC emitted into the atmosphere principally from fuel combustion of petrol and diesel vehicles.

Health Effects:

Possible chronic health effects include cancer, central nervous system disorders, liver and kidney damage, reproductive disorders, and birth defects.

i. Toxic Organic Micro pollutants:

TOMPs (Toxic Organic Micropollutants) are produced by the incomplete combustion of fuels. They comprise a complex range of chemicals, some of which, although they are emitted in very small quantities, are highly toxic or carcinogenic. Compounds in this category include

- PAHs (PolyAromatic Hydrocarbons)
- PCBs (PolyChlorinated Biphenyls)

- Dioxins
- Furants

Health Effects:

TOMPS can cause a wide range of effects, from cancer to reduced immunity to nervous system disorders and interfere with child development.

Global Effects of Air Pollution

a. Acid Rain:

Precipitation is normally acid, theoretically when PH is around 5.5 to 5.6, due to the carbon dioxide in the air as well as the nitrogen and sulphur oxides produced in nature. Rain, snow, or dusts can be made more acid by excessive anthropogenic sources of oxides. There are lots of negative impacts on aquatic systems due to Acid rains. The rain can injure plants if it is sufficiently acidic. The destruction by acid rains is not confined only to plants, lakes and forests. It corrodes building, monuments and metals. It causes serious effects on human health since it contaminates the drinking water.

b. Effect of Air Pollution on Vegetation:

Normal air contains a myriad of gaseous and particulate components. In addition to the principle components nitrogen, oxygen and carbon monoxide, the air contains an array of chemicals that can be considered as air pollutants. Air pollution has an adverse effect on plants. Industrial pollution, particularly from smelters, causes destruction of vegetation. Pollutants from road vehicles also have an adverse impact on air pollution. Necrosis, Chlorosis, Abscission, Epinasty, suppressed growth etc are the effects on plants due to pollutants.

C. Economic Effects of Air Pollution:

Air pollution damage to property is a very important economic aspect of pollution. Air pollution damage to property covers a wide range-corrosion of metals, soiling and eroding of building surfaces, fading of dyed materials, rubber cracking, spoiling or destruction of vegetation, effects on animals, as well as interference with production and services.

Deposition of this acid on the metal parts, building parts of building roofs, eaves, and other metal equipment result in a considerable loss from atmospheric corrosion in most urban communities

V. AIR POLLUTION MONITORING

Sampling and measurement of air pollutants is generally known as air quality monitoring. Air quality monitoring is an integral component of any pollution control programme. Air quality measurement is generally carried out in two different situations. One is ambient air quality measurement, where the pollutant levels in the ambient atmosphere are measured. The second type of measurement generally deals with the pollutants emitted from a source.

5.1 PARTICULATE POLLUTANTS

Particulate pollutants in the atmosphere are grouped generally into those that settle out to the force of gravity and those that remain suspended as aerosols. Settle able pollutants are particles of size greater than 10µm diameter. These can be collected using sedimentation techniques. Suspended pollutants are smaller when compared to settle able pollutants. More sophisticated techniques like filtration, impingement, electrostatic and thermal precipitation are used.

Sedimentation (Dust fall jar)

The simplest device used for sampling particles larger than 10µm in diameter is the dust fall jar collector. A typical collector consists of a plastic jar of about 20 to 35cm height and 10 to 15 cm diameter at the base with a slight inward tapering of the walls from top to bottom.

High-volume Filtration (the High-volume Sampler)

The high volume filtration method is popular for measurement of the mass concentration of suspended particulate smaller than 10µm. In this method, a high-speed blower sucks a known volume of air through a fine filter and the increase in weight due to the trapped particles is measured.

VI. AIR POLLUTION MODELING TECHNIQUES AND SOFTWARE

6.1GENERAL

Road transport is the major source of air pollution in urban areas. It is necessary to quantify emission levels as accurately as possible, with appropriate spatial and temporal resolutions. Estimation of emissions from road vehicles is usually calculated through emission factors dependent of mean speed. The modeling of air pollution produced by traffic activity has been widely used to develop emission inventories, in the urban areas (Zachariadas e al 1997; Barth et al 1996).

Microscale (characteristic lengths below 1km); in general air flow is very complex at this scale, as it depends strongly on the detailed surface characteristics (i.e. form of the buildings, their orientation with regard to the wind direction etc.). Although thermal effects may contribute to the generation of these flows, they are mainly determined by hydrodynamic effects (e.g. flow channeling, roughness effects) which have to be described in an appropriate simulation model.

Mesoscale (characteristic lengths between 1 and 1000 km); the flow configuration in the mesoscale depends both on hydrodynamic effects (e.g. flow channeling, roughness effects) and in homogeneities of the energy balance mainly due to the spatial variation of area characteristics (e.g. land use, vegetation, water), but also a consequence of terrain orientation and slope. From the air pollution point of view , thermal effects are the most interesting, as they are of particular importance at times of a weak synoptic forcing, i.e. bad ventilation conditions.

As a minimum requirement, mesoscale meteorological models should be capable of simulating local circulation systems, as for instance sea and land breezes. Mesoscale atmospheric processes affect primarily local-to-regional scale dispersion phenomena, for which urban studies are the most important examples. The description of such phenomena requires, even for practical applications, the utilization of fairly complex modeling tools.

6.2 DETERMINISTIC MODELS

Deterministic models are also called as process-oriented models. Deterministic air pollution models incorporate descriptions of several physical and chemical phenomena in the atmosphere: starting with emissions, atmospheric advection and dispersion, chemical transformation and deposition.

The Gaussian Plume Model

Gaussian models have been developed by Pasquill (Pasquill 1961) and Gifford (Gifford 1961). Gaussian plume dispersion model designed to predict ground-level concentrations (glcs) due to emissions from one or more sources. Sources may be modelled as point, area or volume sources. The model is generally used in an area of up to a few hundreds of square kilometers around the sources.

Long-term evaluation can be obtained by using the so-called climatological versions of the Gaussian models. In these climatological applications each concentration computed by using the traditional Gaussian expression weighted by the frequency of occurrence of its corresponding meteorological conditions. Short-term Gaussian models are ALHOA, CDM, BLP, CRSTER, DIMULA, HIWAY, ISC, MPTER, PAL, PLUVUEII, and TUPOS etc. In particular CDM, DIMULA and ISC allow long-term simulations.

This model has the following assumptions.

1. Continuous emission from the source or emission times equal to or greater than travel times to the downwind location under consideration, so that the diffusion in the direction of transport may be neglected.
2. The material diffused is a stable gas or aerosol (less than 20μm diameter) which remains suspended in the air over long periods of time.
3. The equation of continuity

$$Q = \int_{0}^{+\infty} \int_{-\infty}^{+\infty} \chi u \, du \, dz$$

   is fulfilled, that is, none of the material is removed from the plume as it moves down wind and there is complete reflection at the ground.
4. The mean wind direction specifies the x-axis and a mean wind speed representative of the diffusing layer is chosen.
5. Except where specifically mentioned the plume constituents are distributed normally in both the crosswind and vertical directions.
6. Standard deviations (σ) used to quantify plume spread are consistent with averaging time of the concentration estimate.

The concentration of a pollutant at a point (x, y, z) generated by a source at a height H can be estimated using the expression.

$$\chi(x,y,z) = \frac{Q}{2\pi\sigma_x\sigma_y u} \exp\left[-\frac{1}{2\left(y/\sigma_y\right)^2}\right]\left\{\exp\left[-\frac{1}{2\left(z-H/\sigma_z\right)^2}\right] + \exp\left[-\frac{1}{2\left(z+H/\sigma_z\right)^2}\right]\right\}$$

where χ= pollutant concentration
(x,y,z) = coordinates of the receptor point
H= height of emission
u= wind speed
Q= the emission rate
σy,σz= standard deviation of plume concentration distribution across the horizontal and vertical dimensions of the plume at the downwind distance x.

6.3 STATISTICAL MODELS

Statistical models are valuable tools in estimating present air quality by means of interpolation and extrapolation of measuring data. These are based on semi-empirical statistical relationships between available data and measurements.

Regression Analysis

Regression analysis is a particular type of multiple time-series analysis in which, for example, meteorological measurements are statistically related to air quality concentration. It is a statistical technique for quantifying the relationship between variables. Linear regression models are easily applied and interpreted.

They require, however, a number of statistical preconditions to be fulfilled, like statistically independent observations and linear relationships. In most atmospheric situations this is not given and therefore the applicability of simple linear regression models is often very limited or the forecasting performance is quite poor. In simple regression analysis, there is one dependent variable to forecast and one independent variable.

More complicated relationships between variables can be readily modeled. For example, several independent variables can be incorporated into the analysis or curvilinear relationships can be handled. Forecasting accuracy heavily depends on the accuracy of the estimates for the independent variable. A consistent relationship between the variables is assumed when making forecasts.

6.4 HIGHWAY POLLUTION MODELING SOFTWARE

6.4.1 Dispersion Modeling Software

A Dispersion Model is a tool used to predict the concentration of a contaminant at a receptor resulting from point, area or volume exhaust sources. Dispersion models use mathematical algorithms that simplify atmospheric dispersion and dilution phenomena. The dispersion modeling is used to predict the concentration of pollutant. These are useful to predict the ambient air quality.

CALINE 4 Model

CALINE4 (Caltrans, 1989) is a dispersion model that predicts carbon monoxide (CO) impacts near roadways. Its main purpose is to help planners to protect public health from the adverse effects of excessive CO exposure. It calculates quantities of pollutants in the air at specified receptors from information on the type and strength of sources of pollutants and information on weather conditions.

The CALINE-4 model allows roadways to be broken into multiple links that can vary in traffic volume, emission rates, height, width, etc. The screening form of the CALINE-4 model calculates the local hourly–averaged contribution of nearby roads to the total concentration.

- Traffic parameters: Traffic volume (hourly and peak), traffic composition (two wheelers, three wheelers, cars, buses, goods vehicle etc.), type of the fuel used by each category of vehicles, fuel quality, average speed of the vehicles.
- Meteorological parameters: Wind speed, Wind direction, stability class, mixing height
- Emission parameters: Expressed in grams /distance travelled. It is different for different categories of vehicles and is a function of type of the vehicle, fuel used, average speed of the vehicle and engine condition etc.
- Road geometry: Road width, median width, length and orientation of the road, number and length of each links
- Type of the terrain: Urban or rural, flat or hilly
- Background concentration of pollutants
- Receptor location

The suggested study methodology is presented in figure 5.1 in the of flow chart form

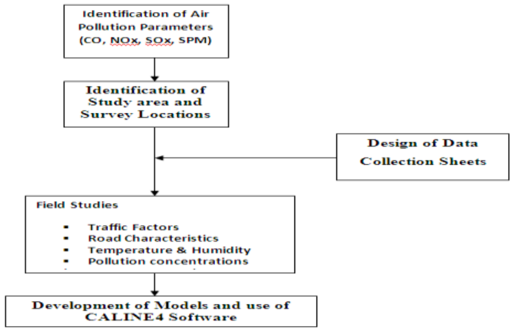

Fig no 4.1 Suggested Methodology for Air Pollution Modeling

VII. PROFILE DETAILS

7.1 STUDY AREA CHARACTERISTICS

Chennai is the capital city of the State of Tamil Nadu located on the southeastern coast of the country. Chennai Metropolitan Development Authority (CMDA) is vested with the responsibility of regulating the developments and accomplishing the planning in the desired direction. The economic base of the Chennai city is a mixed one with small-scale industries and commercial activities distributed over the space of the city.

7.2 TRAFFIC STUDIES

In the foregoing section, study area characteristics have been described. To estimate the loads of pollutants it is necessary to estimate the vehicle kilometres travelled on road network of the city. In order to accomplish these estimates, traffic studies have been carried out extensively on the road network of Chennai.

The traffic studies were designed and conducted not only to quantify the traffic load by vehicle type and fuel type on the road network of Chennai but also to assess the vintage and other characteristics of the vehicles and their pollution levels. The appropriate studies and their methodology are briefly described in the succeeding sections.(Fig.7.1)

Fig No.7.1: Road Network of Chennai Metropolitan Area

7.2MID BLOCK TRAFFIC COUNTS

A total of twenty-one mid block sections and six outer cordons points were selected (as indicated in Figure 1) to conduct classified traffic volume counts. Appropriate proformae were designed to record the number of vehicles moving across the count point during a given time.

7.3 INTERSECTION TURNING VOLUME COUNTS

A total number of ten intersections (as indicated in Figure 1) were selected for conducting traffic counts. Out of this, 12-hour (i.e. 8.00 am to 8.00 pm) turning volume count was done at seven intersections and at the remaining three intersections; survey was conducted for 24 hours.

On the basis of the factors evolved for mid-blocks, the intersection traffic flows have been expanded to 24 hours. A summary of daily traffic volume at selected intersections is presented in Table 2. The composition of traffic by different vehicle types shown in this table illustrates that the two wheelers contributes the major share of about 50 percent followed by cars which amounts to about 15 percent.

7.4OUTER CORDON SURVEYS

A total of six outer cordon points were selected (as already shown in Figure 1) around the city for conducting 24-hour classified traffic volume counts along with roadside Origin - Destination (OD) studies. The main purpose of this study was to assess the quantum of the vehicles entering and leaving the city on normal working days.

7.5 FUEL STATION SURVEY

A total of eighteen fuel stations and two goods terminals within the city were selected to conduct interviews of the owners/drivers of the vehicles visiting the fuel stations/goods terminals. Care was exercised to locate the survey stations across the space of Chennai city so as to obtain the representative sample of the vehicles plying on the city road network.

7.6SPOT SPEED MEASUREMENTS

The quality of traffic flow is judged on the basis of journey speed and running speed of the vehicles. The pollutants in the exhaust will increase with speed changes and the vintage of the vehicles. With a view to understand the quality of flow, spot speed measurements have been made at a few of the selected mid-block locations.

7.7 AIR POLLUTION MEASUREMENTS

With a view to make indicative assessment for the quality of air and its direct relation with traffic, hourly / 4-hourly / 8-hourly air pollution concentrations (of CO, NO2, SO2, SPM, RSPM and THC) has been measured along with the road traffic measurements for every 15 minutes during the survey period. It was observed that there is a fair amount of correlation between the hourly traffic flows and respective hourly concentrations of CO and HC only in the case of sites located within the city.

7.8 TRAFFIC LOADS ON ROAD NETWORK

To validate the vehicle - kilometers traveled, comparison has been made by estimating the vehicle - kilometers travelled on the basis of responses obtained from the driver interviews at the fuel stations and vehicles in use. The estimates of vehicle kilometers traveled as obtained from both the sources are presented. and the following can be inferred from this Fig No 7.2

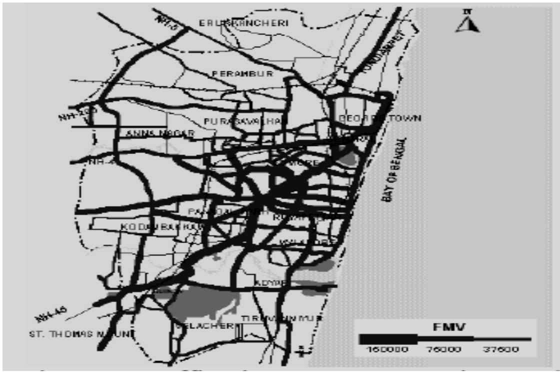

Fig No 7.2 Vehicle-Kilometres Estimated from Roadside Counts and Fuel Stations

It can be seen that the two wheelers (54%) contributing major part to the total traffic followed by cars (20%), autos (17%) and goods vehicles (5%). The buses and taxis are contributing each only about 2% of the total amount of travel.

Though the major road network constitutes only about 12 percent in total length, it carries more than 70% of total traffic volume. This situation clearly warrants for effecting improvements to the major road network so as to achieve smoother and congestion free movement of the traffic.

7.9 ASSESSMENT OF AIR POLLUTION LOADS

For working out the quantity of criteria pollutants (i.e. CO, NOx, HC and PM), an interactive computer program was written in C++ language and input files regarding the quantum of travel and the share of different types of vehicles and their vintage (refer Figure 3) along with appropriate / corresponding emission and deterioration factors (refer Appendix-I) were separately created and used in the computations. Thus, the method used to estimate the air pollution loads is given below:

$$E_i = \sum_i (Veh_j D_j) e_{ijkm}$$

where, Et is the total estimated emission of each pollutant (expressed as g/day or tons/day), Veh_j is the number of vehicles of type j, D_j is the distance travelled by vehicle type j and e_i is the emission factor of vehicle type i (expressed as g/km). The estimated pollution loads using the above method (i.e. given in Eq. 1) as per the category of travel (i.e. inter-city and intra-city) in the city is presented.

7.10 IMPACT OF BYE PASSABLE TRAFFIC ON AIR POLLUTION LOADS

The travel made on city roads by the vehicles coming from outside the city is quite significant in the case of bigger cities like Chennai. Moreover, there is a general feeling that the vehicles coming from outside pollute significantly and they should be bye passed. In this study, the quantum of the intercity traffic touching and passing through the city of Chennai has been estimated. Table 8 gives the volume of traffic as per vehicle type, intercity (entering and leaving) and passing through the city of Chennai. In order to estimate the impact of bye passable traffic on the air pollution loads, the Origin - Destination data (refer Section 4.3) collected from different cordon points was used to find out the mode-wise bye passable traffic and their respective vehicle kilometers.

7.11ASSESSMENT OF FUTURE POLLUTION LOADS

For the assessment of the future travel demand, it becomes necessary to project the travel demand and the corresponding vehicle - kilometers travelled by each class of vehicles by conventionally accepted techniques of travel demand projections [TRB (1978), Oppenheim, N., (1995)]. The approach adopted to project the travel demand is as shown in Figure 6. It involves two steps:

I. Projection of passenger trips and their modal split; and then the vehicle – kilometers travelled by different modes (considering percentage share of trips by Private Cars, Two Wheelers, Buses and Rail).

II. Projection of the vehicle population of commercial vehicles for the future and estimating the vehicle - kilometers travelled (in the case of Autos/Taxis and Goods vehicles) by them.

VIII. RESULTS AND CONCLUSION

Air pollution is becoming a major environmental problem. Even though various sources of air pollution are there, among them vehicular exhausts are becoming major contributors for the air pollution. In urban areas air pollution is produced largely by motor vehicles.

Transport's contribution to urban air pollution is a serious and growing issue because:

- Transport or mobile sources contribute the majority of most pollutants in urban areas, particularly when viewed in terms of human exposure.
- Transport contributes the vast majority of increases in levels of urban air pollution, and The rapidly increasing vehicular traffic is a major contributor to air pollution. Among the vehicular exhausts, Particulate Matter, Carbon Monoxide, Oxides of sulphur are the main culprits for causing health and environmental hazards.

Air pollutants cause adverse health effects if they are present in the air in sufficient concentrations and for a sufficient length of time. Atmospheric pollutants can cause a range of effects on human health and the environment, with the severity of effects often related to the duration of exposure and concentration of the pollutant.

These include:

- Nuisance effects (e.g. decreased visibility, odour)
- Acute toxic effects (e.g. eye irritations, increased susceptibility to infection)
- Chromic health effects (e.g. mutagenic and carcinogenic actions) and
- Environmental effects (e.g. material soiling, vegetation damage, corrosion)

The dispersion modeling is used to predict the concentration of pollutant. These are useful to predict the ambient air quality. For the implementation of effective air pollution control measures, effective pollution quantification is necessary.

The estimated vehicle - kilometer (which is around 25 million) is expected to register a steep increase and touch a figure of 35 million vehicle kilometers by 2010. However, the capacity of roads cannot be easily expanded because of physical constraints imposed by built-up area on either side of the carriageway. Besides this, roadside encroachments are another serious problem in the city as they hinder smooth flow of traffic.

The study has revealed that though the major road network in the city is limited in length, it carries as much as 70 percent of the total traffic loads in the city of Chennai. The base year (i.e. 2002) estimated daily pollution loads of CO, NOx, HC and PM from vehicles is observed to be 177.00 t, 27.29 t, 95.64 t and 7.29t respectively.

Hence, the impact of improvement in engine technology and fuel quality have been explored in this paper by estimating the pollution loads under both BAU and policy options of vehicle technology and fuel quality using the projected vehicle - kilometers of 2010 for Chennai. It can be inferred from this analysis that even if the BAU were allowed to continue till 2010, the pollution loads due to traffic would be marginally lesser than the base year for all the criteria pollutants except NOx.

This is attributable to higher proportion of vehicles of cleaner technologies which are expected to replace the older vehicles in future. To achieve maximum efficiency in traffic operations, it is proposed to develop the major arterial road network of the city as express route system having grade separators and signal free environment as shown in Figure 7. Moreover, the following Traffic System Management (TSM) strategies can be attempted to discourage the use of private automobiles

- Levying of parking charges at the destination (office / shopping) end
- Road Pricing in central areas and heavily trafficked routes
- Prohibiting the entry of particular type of vehicles during the part or whole of the day
- Exclusive bus-lanes and bus ways

It is suggested that the recommended options of Auto Fuel Policy should be strictly adhered along with more stringent Inspection and Maintenance (I&M) norms in the city. Further, it is imperative to explore the usage of alternate fuels such as CNG (as being practiced in Delhi) for public transport vehicles and intermediate Para-transit (i.e. autos and taxis) modes so as to achieve further improvement in air quality of Chennai,. The above-indicated steps are mainly suggestive and needs more detailed technical studies and investigations before embarking on implementation.

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