1 Introduction

The expansion of industries, growth of cities and concentrated human activities are leading to alarming increase in air pollution levels in almost all metro cities of the world [1]. Vehicular, industrial and domestic sources are major anthropogenic categories causing emission of air pollutants into the environment. In recent years, air pollution from industrial and domestic sources has markedly decreased due to passage of various acts promulgated by different governments in most of the countries. However, a substantial growth of motorized traffic over the years has increased the air pollution levels in urban centers [2]. An investigation by Mage et al. [3] have pointed out that motor traffic is a major source of air pollution in mega-cities with a population of over 10 million[1]. In last five decades, the global vehicle fleet has already grown ten fold and estimated to further double in next 20 to 30 years [5]. Much of the expected growth in vehicle numbers is likely to occur in the developing countries [3] with more people driving more vehicles over greater distances and for longer duration; and exposing larger number of people to elevated concentration of ambient air pollutants for longer period causing adverse health effects [6].

[1] Kretzchmar [4] indicated that in the year 1990, already 12 urban cities had population exceeding 10 million, and estimated to double over the next ten years-seventeen of twenty four mega-cities will be in developing countries. By the year 2030, developing country cities are expected to grow by 160 percent.

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1.1 Air Pollution Definition

Many definitions have been proposed to explain the air pollution. In general, air pollution may be defined as *the presence in the outdoor atmosphere of one or more contaminants or combinations thereof in such quantities and of such duration as may be or may tend to be injurious to human, plant, or animal life, or property or reasonably interfere with the enjoyment of life or the environment [7].*

1.1.1 Composition of Atmosphere

The composition of dry atmospheric air up to a height of 50 km is given in Table 1. In addition, air also consists of 1 to 3 percent (volume/volume) water vapor and tracers of sulfur dioxide (SO_2), formaldehyde (HCHO), iodine (I), sodium chloride (NaCl), ammonia (NH_3), carbon monoxide (CO), dust and pollen.

Table 1 Compositions of dry atmospheric air.

Chemical compound	Concentration (ppm)[a]	Concentration ($\mu g/m^3$)[b]
Nitrogen (N_2)	780,000	8.95×10^8
Oxygen (O_2)	209,400	2.74×10^8
Argon (Ar)	9,300	1.52×10^7
Carbon dioxide (CO_2)	315	5.67×10^5
Neon (Ne)	18	1.49×10^4
Helium (He)	5.2	8.50×10^2
Methane (CH_4)	1.2	7.87×10^2
Krypton (Kr)	1.0	3.43×10^3
Hydrogen (H_2)	0.5	4.13×10^1
Xenon (Xe)	0.08	4.29×10^2
Nitrous oxide (N_2O)	0.5	9.00×10^2
Ozone (O_3)	0.01-0.04	$1.96 \times 10^1 – 7.84 \times 10^1$

[a] parts per million; [b] micrograms per cubic meter

1.2 Air Pollution Problems

Air pollution problem was first experienced in the year 1272 in England. King Edward I, enforced law prohibiting the use of *sea-coal* in furnaces. In 1873, a fog in London reported death of 268 people due to bronchitis problems [7]. Later, during 19th century, a number of air pollution related problems occurred. In December 1930, a heavy industrialized sector of the Muse Valley in Belgium, experienced a severe three day fog resulting into death of 60 persons. In January 1931, 592 people died in Manchester and Salford area of England due to thick fog hovering over the city for nine days. In 1948, in Donora, Pennsylvania, a small town dominated by steel and chemical plants in the USA, about 6000 inhabitants fell sick due to thick fog persisted for four days. A major air pollution disaster hit the London city in December 1952. A thick fog lasted for ten days resulting into death of 4000 people due to asphyxiation. In July 1976, sudden release of the dioxin due to reactor explosion in Seveso, Italy resulted into illness of 187 people. Recently, in December, 1984, release of 30 tones of deadly methyl isocynate gas from storage tanks due to failure of vent scrubber system in Bhopal, India, killed 2500 persons and severely affected the health of more than one lakh people in vicinity of the city [7, 8, 9]. These 'episodes' are mainly caused from 'point/area' sources favored by worse meteorological conditions. However, rapid urbanization of urban regions in last two decades resulted into their exponential growth in almost all over the world. Due to this many urban centers have become 'hot-spots' experiencing frequent 'exceedance' in pollutant concentrations. Motorized traffic is one of the major causes of deteriorating air quality in such urban centers.

Several studies in the past have been carried out investigating the fate of vehicular pollution in such 'hot-spots'. Organisation for Economic Cooperation and Development (OECD) describes the regional and global impacts of vehicular emissions, with more emphasis on impact of vehicular pollution on local urban air quality [10]. A review of road transport emissions and their impact on the environment at all scales from local to global has been reported in Faiz [11]. The Royal Commission on Environmental Pollution has published a comprehensive report on environmental impact of vehicular pollution [12]. Joumard [13] has described the application of end-of-pipe technology for the abatement of vehicular pollution. Recently, Colvile et al. [14] have reviewed impact of vehicular pollution on human health as well as tropospheric ozone productions.

1.3 Air Pollution Sources

The sources of air pollution are broadly classified into *two* categories, namely, *natural* and *anthropogenic* sources. Volcanic eruptions, forest fires, dust storms are few examples of *natural* sources. *Anthropogenic* sources consist of *stationary* and *non-stationary* (moving) sources. *Stationary* sources are mainly industries and *non-stationary* sources are mainly transport. Further, the *stationary* sources are termed as *point* sources (single industry) and *area* sources (clusture of *point* sources and urban homes). The *non-stationary* sources are mainly vehicles (*line* sources) and other transport means e.g., aeroplanes and railways.

1.3.1 Point Source Emissions

The modelling of point source emission uses Gaussian equation to estimate and predict the spatial and temporal dispersion of air pollutants [8].

1.3.2 Area Source Emissions

An area source is a two-dimensional structure with a limited vertical height. The fundamental approach to developing a diffusion model for area sources is to apply conservation of mass for a particular pollutant with appropriate boundary conditions [15]. The simplest area source model is the BOX model [16]. The pollutant is assumed to be completely mixed within a single box which covers the city and extends upward to the mixing height[2].

[2] The mixing height is the height above which pollutants do not rise due to temperature profile of the atmosphere.

1.3.3 Line Source Emissions

The vehicular pollution dispersion from roadways is modeled as *line source* or *series of point sources*. The *line source* approximation involves solving an integral equation along the specified line, which results in greater computational requirement than the approximation as a series of point sources. However, in both cases, the estimates of emission concentration are based on Gaussian model formulation [17].

1.4 Urban Air Pollution Control Strategies

Urban air pollution control has two major aspects-'strategic' and 'tactical'. The former is the long-term reduction of pollution levels at all scales of the problem from 'local' to 'global'. Long-term strategies are developed by setting goals for air quality improvement for 5, 10 or 15 years ahead and plans are made to achieve the objectives. On the contrary, the 'tactical' approach aims at prevention and control of 'episodes' to prevent an impending disaster. The duration of such 'episodes' usually varies from 36 hours to 3 or 4 days [8].

1.5 Modelling Tools – Conventional and Soft Computational Approach Including ANN

The conventional Gaussian based models are best suitable to predict long-term average concentrations with frequency distribution up to 90 percentiles. These models are deterministic models of 'causal' in nature. However, their predictive performance is considerably reduced when there exist complexities in temporal and spatial relationship between dependent and independent variables. One of the application domains where the Gaussian based models terribly fail in describing the dispersion phenomena is the urban air sheds. Urban air sheds consist of one or more air quality control regions(AQCRs)[3]

[3] It may be defined as fixed boundaries / areas where local authorities are entrusted with the responsibility for assessing and reviewing the local air quality in conformity with the national ambient air quality standards (NAAQS).

wherein pollutant dispersion is affected by complex traffic movements, road geometry, meteorological conditions and roughness elements. Statistical based models comparatively perform better than the deterministic Gaussian based models in such urban air sheds. These models use various statistical theories in estimating/ predicting pollutant concentrations relating time series data on traffic and meteorology. However, the variation in time series data is complex and non-linear and requires prior assumptions concerning their distribution. As a result statistical based models ‘underperform’ when applied in complex urban air sheds [18]. Artificial neural network based models overcome these shortcomings to some extent because of their special properties like, self-correction, self-learning and parallel processing. As a result these models are able to describe the complex non-linear dispersion phenomena in such urban air sheds and accurately predict the ‘exceedances’ in pollutant concentrations.

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