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Vehicular Emission Monitoring Using Internet GIS, GPS and Sensors

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Abstract. It is well known fact that due to tremendous increase in use of private, public and personal vehicles in mega-cities, the Air Pollution has been up by many folds causing damage to urban public health and properties. Thus, it has become necessary that the concentration of Air Pollutants be monitored regularly to take appropriate decisions to mitigate the same. This paper deals with the real time monitoring of Air Pollutants using solid state gas sensors with ARM module that connects the measured Air Pollution levels to GIS and Internet so that the pollution levels shall be known in no time with one click on Net from any place. These data can be utilized by Public, Government and Non-governmental organizations for appropriate decision to protect public health and properties.

Keywords: Air Pollution, Public Health, Solid State Gas Sensors, ARM module

1. Introduction

Air pollutants have environmental impact on public health, properties, and vegetation, etc. To prevent or minimize the damage caused by atmospheric air pollution, suitable monitoring systems are urgently needed to measure and quantify pollutants concentration by regulating authorities in order to prevent further deterioration of the current air quality status. Air pollution is a serious problem in thickly populated and industrialized areas in Chennai. The air pollution in Chennai is high, especially in areas where pollution sources and the human population are concentrated. Economic growth and industrialization are proceeding at a rapid pace, accompanied by increasing emissions of air polluting sources especially transportation in urban areas. The development of a suitable method for monitoring the atmospheric air pollution in urban areas has not followed at the same pace. Some of the main factors identified as reasons for increasing vehicular air pollution in the Indian mega-cities can be put together as follows;

- High volume of traffic and urban population dynamics
- Excessive increase in private / personal vehicles
- Improper maintenance of vehicles
- Growing traffic bottlenecks
- Less Eco-friendly mode of transport and fuel technologies
- Lack of comprehensive fiscal strategies to check the increase of private / personal vehicles

So as to carry out air pollution monitoring over an extensive area, a combination of ground measurements through inexpensive sensors and wireless and internet GIS was used for this purpose. This portable device, comprising solid state gas sensors integrated to a Personal Digital Assistant (PDA) linked through Bluetooth communication tools and Global Positioning System (GPS) allowed rapid dissemination of information on pollution levels at multiple sites simultaneously. The Air Quality report generated

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published using Internet GIS to provide a real-time information service for the Pollution Control Department (PCD), for increased public awareness and enhanced public participation.

1.1. Need for the Study

Currently, in India, air pollution is widespread in urban areas where vehicles are the major contributors and in a few other areas with a high concentration of industries and thermal power plants. Vehicular emissions are of particular concern since these are ground level sources and thus have the maximum impact on the general population. Also, vehicles contribute significantly to the total air pollution load in many urban areas. Hence there is need for easy and effective method of continues air quality monitoring which can create a great awareness among people and for the Pollution Control Board. Using this continues data necessary steps may be taken to reduce pollution.

1.2. Current Scenario

In India, the number of motor vehicles has increased from 0.3 million in 1951 to 115 million in 2010. The number of two wheelers registered has increased from 38.56 millions in 2001 to 82.40 million in 2010 registering an increase of 114% over the period, while the number of Light Motor Vehicles (passengers) and Jeeps showed a impressive growth of 78% and 46% respectively during the same period. The total number of cars registered has increased from 5.30 million in 2001 to 12.37 million in 2010 which show a growth of 133% during the period. In contrast, the total road network has increased only 8 times from 0.4 million kms in 1950-51 to 3.3 million kms in 1995-96. The slow growth of road infrastructure and high growth of transport performance and number of vehicles all imply that Indian roads are reaching a saturation point in utilising the existing capacities. The drastic increase in number of vehicles has also resulted in a significant increase in the emission load of various pollutants. The quantum of vehicular pollutants emitted is highest in Delhi followed by Mumbai, Bangalore, Calcutta and Ahmadabad, Chennai. Vehicles are a major source of pollutants in metropolitan cities. In Delhi, the daily pollution load has increased from 1,450 tonnes in 1991 to 3,000 metric tonnes in 1997 (MOEF 1997). The share of the transport sector has increased from 64% to 67% during the same period while that of the industrial sector (including power plants) has decreased from 29% to 25% (MOEF 1997).

1.3. Ambient Air Quality

Under the National Ambient Air Quality Monitoring (NAAQM) network, four air pollutants, namely, SPM, CO, SO_2 and NO_2 have been identified for regular monitoring at all the 290 stations spread across the country. The most prevalent form of air pollution appears to be SPM although there are many stations at which CO, SO_2 and NO_2 levels exceed permissible limits. The high influx of population to urban areas increase in consumption patterns, unplanned urban and industrial development and poor enforcement mechanism has led to the problem of air pollution. The government has taken a number of measures such as legislation, emission standards for industries, guidelines for setting up of industries, environmental audit, EIA, vehicular emission norms, etc.

2. Methodology

The study was meant for Chennai City and the vehicular air pollution was measured continuously and published on the website developed for this study. The Chennai city map was digitized with GIS & GPS software by moving around the city then the digitized map was fed into the internet. The three gas sensors that measures three gases namely, CO, NO_2 and SO_2 are linked with GPS through ARM circuit and the data is transferred through laptop and then it was uploaded to internet so that people throughout the world can view the pollution level of particular place in Chennai at any time using the website.

ARM Processor is a type of processor which is used to link different types of outputs. It also helps in uploading the linked data to the internet. This ARM Processor and outputs are collectively known as ARM Module. The above said three sensors and GPS are linked through ARM module, then it is fed into the server from there it is uploaded to the internet as shown in Fig. 1. The Pollution data can be viewed through the web page (www.airpollutioninfo.com). Hence the public can view the level of pollution in a particular place using the website.

The LPC2119/LPC2129 is based on a 16/32 bit ARM7TDMI-S, CPU with real-time emulation and embedded trace support, together with 128/256 kilobytes (kB) of embedded high speed cache memory. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at maximum clock rate. For critical code size applications, the alternative 16-bit Thumb Mode reduces code by more than 30 % with minimal performance penalty. With their compact 64 pin package, low power consumption, various 32-bit timers, 4-channel 10-bit ADC, 2 advanced CAN channels, PWM channels and 46 GPIO lines with up to 9 external interrupt pins these microcontrollers are particularly suitable for automotive and industrial control applications as well as medical systems and fault-tolerant maintenance buses. With a wide range of additional serial communications interfaces, they are also suited for communication gateways and protocol converters as well as many other general-purpose applications.

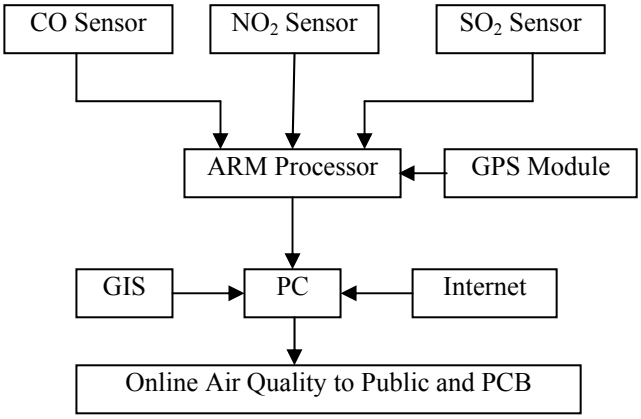

Fig. 1: Flow chart showing the Air Quality Monitoring System

3. Experimental Investigation

Three important routes in Chennai were selected namely Route 1: Avadi to Tambaram (this route covers some of the important, official and commercial areas of the city like Ambatur, Dunlop, Koyembedu, Vadapalani, Udayam, Airport, etc,.) Route 2: Kovalam to T. Nagar (This route covers tourists places like MGM, VGP, KOVALAM, MAYAJAL etc,.) and Route 3: Avadi to Chennai Central (this route covers all type land uses namely Industrial, Educational, Residential, official and recreational the areas covered are Ambatur, Annanagar, Kilpauk and Chennai Central). These three routes on which the data collected is presented in Fig. 2 and Arc View GIS is used for this purpose. The gas sensors and GPS are fitted in car and same connected to a car battery for power supply. The GPS and gas sensors are further connected to ARM processor. The air pollution monitoring survey is carried in the above said three routes in the afternoon session the starting and ending time of survey was kept same in order to get relevant data. On each route, one month data was collected and the average values of CO concentration observed is presented in Fig. 3 (Avadi to Tambaram).

Fig. 3 shows the concentration of CO measured for the route Avadi to Tambaram. In this route the concentration of CO levels varied from 0.1 to 5 ppm. It shows that the vehicle pollution is higher in this route. Similarly the concentration of CO measured for the Route 2 and 3 the maximum and minimum values are 0.1 to 6 ppm and 0.1 to 8 ppm respectively. As per the norms of Pollution Control Board (PCB), the CO level should not exceed 8 ppm in industrial areas, 3.2 ppm in residential areas and 1.6 ppm in sensitive areas. Thus, in all the three routes measured CO concentrations are above the norms of PCB in most of the areas.

Hence the developed tool kit can be used for measuring mobile emission and the kit can be used in other routes and the pollution levels can be made available through the internet for public and private purposes. If the same system is implemented by the government, it is easy for the public to know about pollution levels particularly hazardous gas emission from the industries. The following are the advantages:

- Old methods are more time consuming.
- Public can know the pollution data without any aid of technical persons.
- It is real-time based system when compared to other methods.

- It is useful for Pollution Control Board to view pollution data and to rectify or take necessary steps to control pollution.
- It can be used to monitor industrial pollution by placing near the chimneys to obtain virtual data.
- It is cost effective compared to other methods

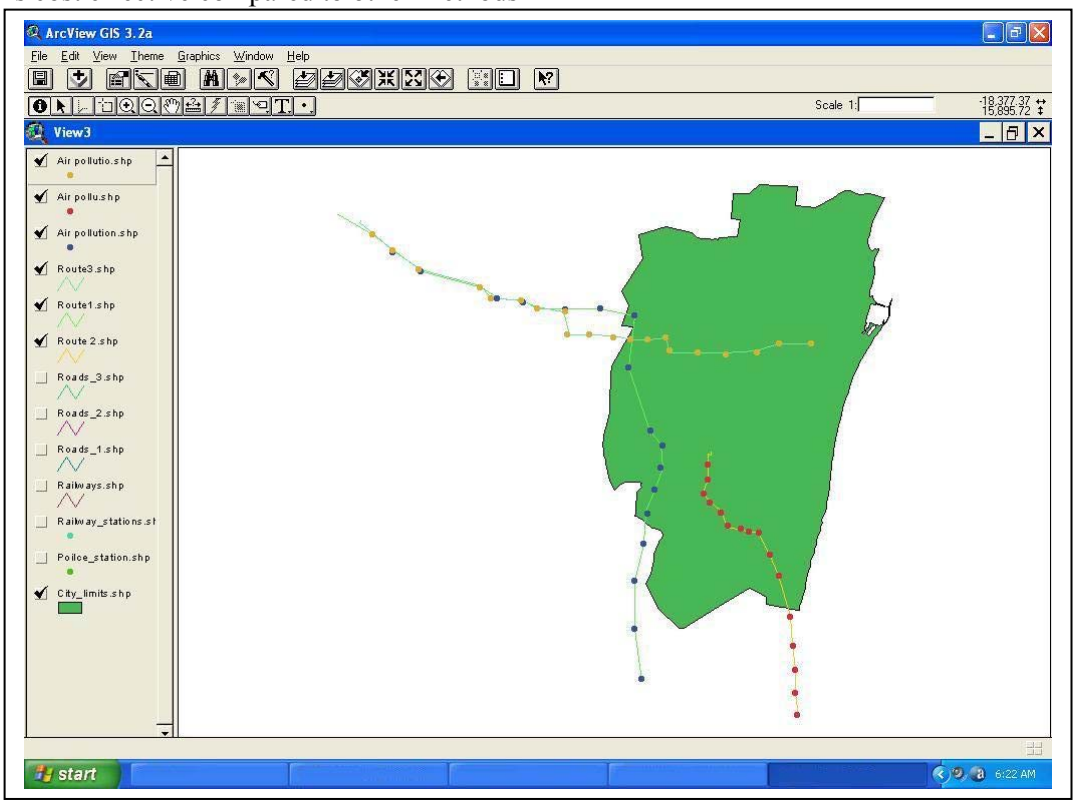

Fig. 2: Study Area Showing the Three Routes

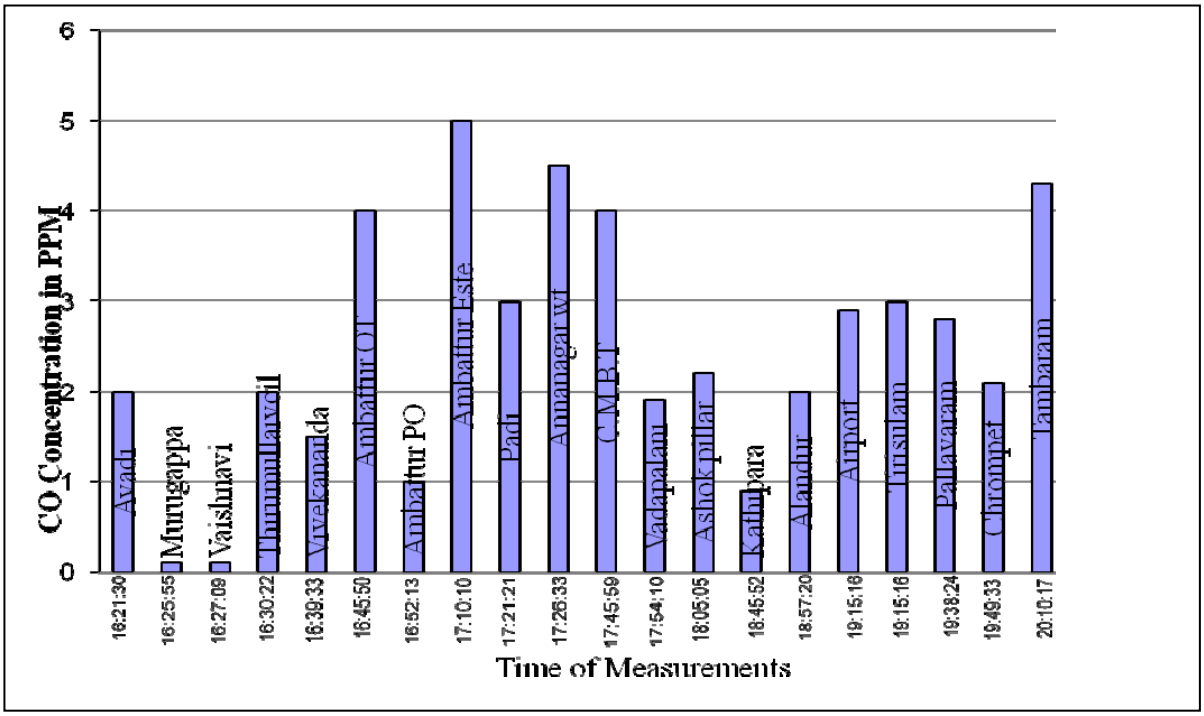

Fig. 3: Concentration of CO Observed in Route 1 (Avadi to Tambaram)

4. Conclusions

Current air quality is better than a decade ago. However, Chennai still has been facing serious air pollution problems. As seen in Chennai, black and white smoke from truck and public bus exhaust still

occurs. This is attributed to the rapid economic and industrial growth, combined with a lack of strict implementation of air quality and requires the PCB to adapt or extend the current PCB's air quality monitoring systems and also facilitate the problem of analyzing and monitoring air pollution in Chennai.

The traditional air quality monitoring system, controlled by the PCB, is extremely expensive. Analytical measuring equipment is costly and time consuming, and can seldom be used for air quality reporting in real time. The PCB has been forecasting and reporting real time air quality levels through the Internet in the form of maps. However, the air quality index of each monitoring site is just shown by rather coarse levels; good, moderate, unhealthy, very unhealthy and hazardous.

The air quality report should be more in detail, including information such as air quality interpolated maps, relating to other information for better understanding the air quality level. For these reasons, this work is aimed to build up an easy monitoring system using low cost portable gas sensing systems 'solid state gas sensors' so as to carry out air pollution monitoring over an extensive area and to be able to report real time air quality data through Wireless Internet GIS. To facilitate the problem of analyzing and monitoring air pollution and also to assist in establishing priorities and measurements of air pollution in the Chennai city this method is proven to be much useful.

4.1. Future Scope of the Study

In this study only one mobile setup is being made but this can be extended to number of stations by buying more gas sensors, and all the data's from different stations can be brought into a single receiver station and same can be uploaded into the internet. This study can also be extended for monitoring various industrial air pollutants and a technical alert system can be setup for PCB to monitor major industries causing pollution. This study may be extended further for the following

- To monitor pollution for different environmental conditions.
- To monitor pollution levels from industrial chimneys
- To monitor pollution levels from industrial sewage

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