NOVEL STRATEGIES FOR ASSESSMENT OF AMBIENT AIR QUALITY USING GIS AND ONLINE POLLUTION MONITORING TOOLS

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ABSTRACT

In recent years, research on air quality has increasingly become an issue of critical importance and quite often a heated topic of debate in view of the accumulating evidence showing the adverse effects of pollution on human health, agricultural crops, man-made environments (damage to building materials) and ecosystems. Suitable selection of the representative air pollution sampling sites for the ground based air pollution and meteorological monitoring is of utmost importance to assure that the data generated is representative of the regime to be investigated. The use of appropriate and standardized criteria for site selection and monitoring protocols is critical if the representativeness and comparability are to be met. The data quality objective for representativeness is subjective in nature and therefore can only be achieved through standardization of the protocols for site selection and sampling.

The present paper highlights the standardized protocol and applies the criteria to evaluate potential locations

for air monitoring site in Hyderabad describes in detail the design and development of Web based online pollution monitoring station using TCP/IP protocol and advanced electrochemical sensor systems. As a result, environmental agencies can directly disseminate air quality information through their websites. The online real-time monitoring system at representative site will enable the policy makers to quantify the spatial variability of major air pollutants like SO_x, NO_x, SPM, RSPM and heavy metal and to study the contribution of different sources

INTRODUCTION:

In the last 50 years, most of mankind has been transformed into city dwellers. However, this rush towards urbanization has brought a multitude of problems, including air pollution, whose consequences are just beginning to be recognized[1]. Urban and regional planning is regarded as a possible tool for a limited but precious resource use control, and as a means to assure a better air quality. Actually, it's a common practice to find planning on a strong sense of responsibility towards the natural environment to avoid a further crisis of the settlement system. Consequently, an integrated study of identification of appropriate sites for representative evaluation of pollution, novel means of monitoring air quality quality, identifying the predominant sources of pollution, assessment of quality, and evaluation of different management strategies becomes essential for the development of a healthy and a livable region. The present paper highlights the systematic and detailed studies carried out on the multi-objective air pollution monitoring site design and development of advanced electrochemical sensors based online pollution monitoring system to continuously monitor the pollution in Hyderabad, AP, Indian urban environment.

METHODOLOGY:

The starting point is the identification of the multi-objective air quality monitoring network using site selection criterion, then development of online air pollution monitoring system. The point data information on the nature of site, number of residential, commercial, industrial and educational and hospital establishments near the site are generated for the city using GPS. The multi-objective air pollution monitoring sites are selected using evaluation of general and site-specific criteria for each proposed site in GIS environment that may, on a local basis, effect the representativeness of the data collected. Local features that may affect either the chemical or meteorological parameters and long term station operation i.e. logistics are also evaluated to assure a minimum of interference.

Figure 1 shows the conceptual framework for the development of online electrochemical sensor based pollution monitoring system. The system uses electrochemical sensors for sulphur dioxide, carbon monoxide, nitric oxide, nitrogen dioxide, mercaptans, hydrogen sulfide, hydrocarbons and ozone. The system also continuously monitors PM_{10} / $PM_{2.5}$, sound level and meteorological parameters such temperature, wind speed, wind direction, rainfall, humidity and barometric pressure.

RESULTS & DISCUSSION

Selection of multi-objective air quality monitoring stations:

A variety of possible data inputs should be considered in selecting the current and future online air pollution monitoring network sites. The criteria used to evaluate potential locations for air monitoring site include interpolation of air pollution isopleths using inverse

distance weighing method[2, 3], population density maps, potential sensitive locations and source locations.

For the city of Hyderabad and the surroundings, the area of investigation of 20 km × 20 km is carried out. Initially, a grid is superimposed over a map of the area of interest. The intersections of the grid lines every variable areas ranging from 100 meters to 40 km depending upon the scale of measurement are used as potential areas for the selection of air pollution monitoring sites. The following suggested guidelines are evaluated for selecting the number and locations of the sampling sites. 1) The area should be the zone of highest pollution concentration within the region; one or more stations are to be located in the area 2) Close attention should be given to densely populated areas within the region, especially when they are in the vicinity of heavy pollution concentration levels 3) The quality of air entering the region is to be assessed by stations situated on the periphery of the region; meteorological factors (e.g., frequencies of wind directions) are of primary importance in locating these stations. 4) Sampling should be undertaken in areas of projected growth to determine the effects of future development on the environment 5) near hospitals and educational institutions 6) the overall placement of sampling stations should also consider the previously operated air pollution monitoring station in the study area.

By performing the overlays functionality in GIS based on population, air pollution concentration, meteorological conditions and existing pollution monitoring stations, and hospital locations probable air pollution monitoring sites are identified. Once suitable sites have been identified, certain local factors are taken into account in selecting the precise location for the monitoring station.

The broad aim of the selection procedure is to select a site that is broadly representative of the quality of the air experienced by people in that part of the city. 1) The site should be located where a significant number of people spend their time 2) It should be in as open a setting as possible in relation to surrounding buildings. 3) Immediately above should be open to the sky, with no overhanging trees or buildings. 4) The sample intake should be no higher than 10 m above local ground level and ideally less than 5 m. (5) there should be no major sources of pollution within 50 m e.g. a large multi-storage car park. (6) There should be no medium sized sources within 20 m e.g. petrol stations, ventilation outlets to catering establishments etc. (7) Cars/vans/lorries should not be expected to stop with their engines idling within 5 m of the sample inlet. (8) The site should not be within (a) 30 m of a very busy road (>30,000 vehicles/day) (b) 20 m of a busy road (10,000-30,000 vehicles/day (c) 10 m of any other road (<10,000 vehicles/day). Based on the above analysis 22 sites are identified for monitoring urban scale air pollution in Hyderabad. Figure 2 – 3 shows the various types of monitoring sites suggested for air pollution monitoring in Hyderabad.

Online air pollution monitoring system:

A monitoring system of electrochemical sensors for air pollutants such as Sulphur dioxide, Oxides of nitrogen, Carbon monoxide, Hydrocarbons, ozone, mercaptans and hydrogen sulphide sensors, Particulate matter monitoring system based on Tapered Element Oscillating Microbalance (TEOM) is developed in to the online air pollution monitoring system. In order to predict the concentration distribution and dispersion online monitoring of major meteorological parameters has been included for temperature, pressure, humidity, wind direction and wind speed measurement.

The data acquisition system consists of hardware (computer, monitor and printer) and provides reports, data storage and screen displays. The software is multitasking, allowing several programmes to run simultaneously. The data from the sensors will be fed to a data logger, which in turn transmits to the central monitoring station. After appropriate data verifications functions, using “Internet protocol” technology, the pollution data will be transmitted to the web.

A specially designed data logger for air pollutants concentrations has been included as part of the system. The measurements are automatically transferred from the monitoring station to central database for quality control. Each of the pollution analyzers feeds data to the data logger, which stores the data with time. The data logger is capable of storing one day’s worth of information. The central pollution monitoring division PC automatically collects the data. There is also the capability to ‘manually’ collect the data at any other time, if required. This data automatically loaded into the database and in this format it will be used to generate reports on a daily, hourly basis. The unique ID address or serial number of each monitoring station is the key to interpret from which sampling area the data belongs.

Data quality control is performed at different levels in the data collection procedure in the field during automatic and manual calibrations at the central database where calibrations are performed. The data archival and data presentation with data validation protocols using CRC (cyclic redundancy checks) checks is developed to monitor pollution levels at every ½ hour duration during peak hours and at 1-hour interval during normal hours.

Calculation of pollution indices in air pollution monitoring:

Vast amount of data that are generated as a result of air quality monitoring programmes complicates the meaningful interpretation (of data) and demands extensive statistical and computational efforts. Air Quality Index (AQI), although a useful tool devised to simplify interpretation of data, may result in some loss of scientific information. In this research, adaptability of some of the existing AQIs that have been used by various agencies is examined[4]. Care has been exercised to make the index (and functions to calculate sub index) compatible with the Indian National Ambient Air Quality Standards.

The pollutants included in the index are: $S0_2$, SPM, 0_3, $N0_2$, PM_{10}, CO and SO_2 SPM. The index is classified in five categories; 0-100 good, 101-200 moderate, 201-300 poor, 301- 400 very poor and 401-500 severe. The other important aspect of AQI is the dissemination of index with additional information to general public.

Data Presentation:

For this purpose, a website (appcb.org/pcb/home.htm) is developed for display of stations air quality as well as quality index. The website is comprehensively designed to indicate the pollutant responsible for index and the pollutants exceeding the standards. The developmental website facilitates for inter/intra city comparison of AQI for online as well as historical data of air quality. The general public can access the information through interact and the other media agencies like newspaper, TV, radio can also down load the information and disseminate the information.

Conclusions:

The application of decision support tools is an opportunity to improve air quality planning for the larger cities in India. Comprehensive systems should ideally include the following main elements air quality monitoring, emission inventories, air quality exposure

mapping, impact assessment of different traffic abatement measures, information to the public as well as forecasts for e.g. next day levels. The system combining the latest sensor and monitor technologies with data acquisition; data base developments, quality assurance, statistical and numerical models are definitely one stride to the fore to select the right actions in the process of preventing health related damages. The system is designed to deliver real time data on various pollution ½ hr intervals during peak hours and 1hr during normal hours and can be accessed on the hyperlink 24 hr a day www. appcb.org/home.htm.

References:

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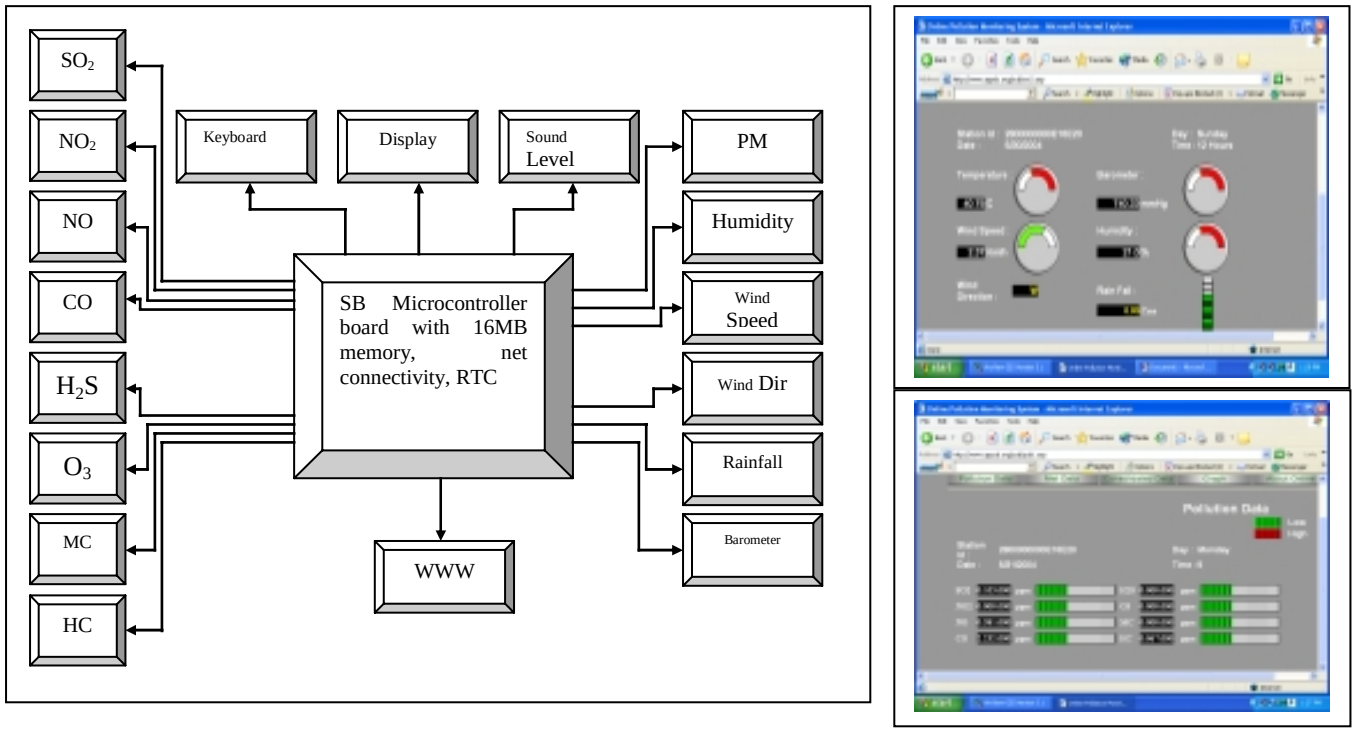

Figure 1 Conceptual framework of online air pollution monitoring system and the web page displaying pollution information

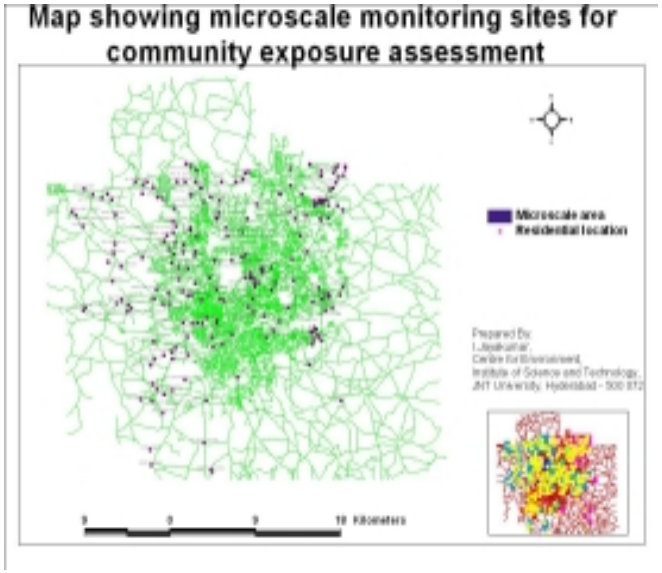

Figure 2 Map showing microscale (100meters) monitoring sites for community exposure assessment

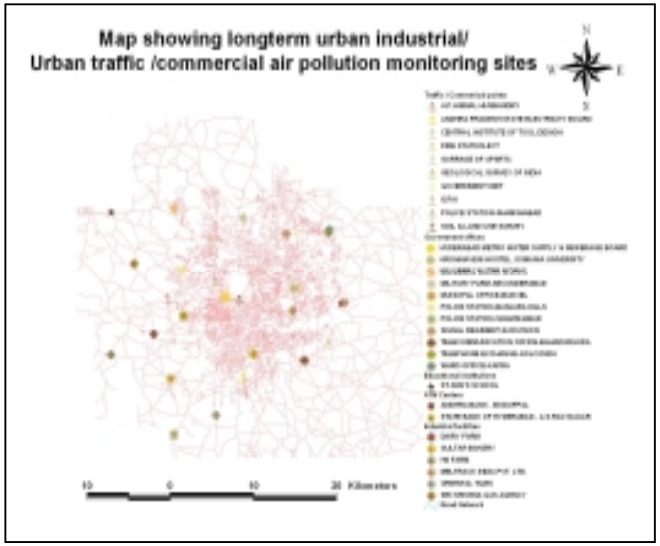

Figure 3 Map showing long-term urban/ industrial/ urban traffic and commercial air pollution monitoring sites