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Design of a website for dissemination of air quality index in India

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Abstract

An air quality index (AQI) system, including web-based AQI information dissemination software designed for India, is presented in this paper. The website is designed for online calculation and display of nation-wide AQI. The site (http://home.iitk.ac.in/~mukesh) is currently active for historical data (1988–1998). The website renders a quick, simple and an elegant looking response to an AQI query. The display of AQI is through an air quality-meter with animation and colors for various index categories. The other features of the website include reporting of pollutant responsible for index, pollutants exceeding the standards, health effects with facilitates for inter/intra city comparison of AQI using multiple windows. In all, over 70 cities/towns with over 270 locations (spread all over India) are covered on the website.

Keywords: Air quality index; Web-design; Information dissemination; India

1. Origin and concepts of air quality index

Air is the prime resource, in addition to the land and water, for sustenance of life. With the rapid technological advancements, vast amount of data on ambient air quality is generated to understand the quality and to administer appropriate corrective actions. Such an endeavor results into encyclopedic volumes, which may neither give a clear picture to decision makers nor to a common man who simply wants to know how good or bad the air is.

As for general public, the questioner usually will not be satisfied with raw data, time-series plots, statistical analysis and other complex findings pertaining to air quality. The complexity in information often results in loss of interest among the people and they can neither appreciate the state of air quality nor the pollution mitigation efforts undertaken by regulatory agencies. Also, awareness of the daily air quality levels of urban air pollution is often important to those who suffer from illness, caused by air pollution. The success of the nation's commitment to improve the air quality depends on the support of its citizens who are well-informed about local and nation-wide air pollution problems and about the progress on abatement of pollution.

With an objective to address the above concerns, concept of air quality index (AQI) has been developed and used effectively in many industrialized countries for over last three decades (Babcock and Nagda, 1972; USEPA, 1976, 1998). AQI is defined as an overall scheme that transforms the weighted values of individual air pollution related parameters (e.g. SO_2, CO, visibility, etc.) into a single number or set of numbers. The result is set of rules (for example, an equation) that translates parameter values into a more parsimonious form by means of numerical manipulation.

Development of proper AQI and a mechanism to disseminate the index values to general public are essential for successful index system. The conventional methods for information dissemination include reporting on radio, newspaper and television. In recent times, Internet being so widely accessible, any information can be disseminated quickly online with additional and historical data through website. As a result, most environmental agencies directly disseminate air quality information through their website (e.g. USA—http://epa.gov.in/airnow).

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Website must be designed to send a quick, simple and an elegant looking response for AQI dissemination to general public and decision makers and for those interested in analysis of data.

The objective of this paper is to describe an AQI and web-based information dissemination system in India. The website has been developed for online calculation of nation-wide AQI and its display on an air quality-meter with animation and colors for various categories. The website is comprehensively designed to indicate the pollutant responsible for index and pollutants exceeding the standards. The developed website facilitates inter/intra city comparison of AQI using multiple windows. There are 70 cities with over 270 locations (spread all over India) covered by the designed website. At present, the air quality data of 11 years (1988–1998) are stored on the webserver and efforts are being made to make the current data available on the site. The source of data is from National Ambient Air Monitoring (NAAM) Program of Central Pollution Control Board (CPCB), New Delhi. It may be noted that data are not available for each day, as the frequency of sampling is only twice in a week.

2. Description of air quality index

The detailed description of the developed AQI is given in Sharma et al. (2001), however, a brief description of the index is given subsequently so that readers can appreciate the AQI formulation. While designing the AQI, the following points have been considered: (i) number of pollutants; (ii) calculation mode; and (iii) description categories and criteria. The major air pollutants, which could cause potential harm to human health, have been included in the proposed AQI. These pollutants are suspended particulate matter (SPM), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter of less than 10 μg in size (PM_{10}) and Ozone (O_3). It may be recognized that concentrations of not all six pollutants are necessary to calculate the index, although desirable. The way index is designed, at the minimum, three pollutants SPM, SO_2, and NO_2 are sufficient to calculate the index. While designing the website (described later), it is ensured that pollutants considered for calculating the AQI are displayed on the website.

To reflect the status of the air quality and its effects on human health, the ranges of index values have been categorized as: *good*, *moderate*, *poor*, *very poor* and *severe*. The key reference point in the proposed AQI is the value of 100 (the 'safe' limit), which is based on attainment of National Air Quality Standards (NAQS) for residential area in India (Sharma et al., 2001). Primarily two steps are involved in formulating an AQI: (i) formation of sub-indices for each pollutant, and (ii) aggregation of sub-indices. For the proposed index, maximum operator system has been selected, as the maximum operator system is free from the problems of eclipsing and ambiguity (under or over reporting of air pollution levels). Over all AQI calculation system is shown in Fig. 1.

A segmented linear function is used relating the actual air pollution concentrations (of each pollutant) to a normalized number (i.e. sub-index). The basis for these linear functions (for this study) is arrived after considering such functions adopted by other countries/agencies (GVAQI, 1997; Malaysia, 1997; Ontario, 1991; UK, 1998; USEPA, 1976, 1998) and views of other experts (readers can also visit the website http://home.iitk.ac.in/~mukesh for details on index and cut off points for index categories). Table 1 shows linear segmented relationship for sub-index values and pollutant concentrations. The proposed index has been given the name Indian air quality index (IND-AQI). The categories of index system are:

IND-AQI	Descriptor
0–100	Good (compliance of NAAQS)
101–200	Moderate (compliance of NAAQS of USEPA)
201–300	Poor (alert level)
301–400	Very poor (warning level)
401–500	Severe (emergency level)

3. Design of website

A flowchart (with explanation) for the design of the website is presented in Fig. 2.

4. Implementation of website

The address of the designed website is http://home.iitk.ac.in/~mukesh. Readers are encouraged to visit the site and send comments and suggestions (e-mail/contact address is given on the left-side of the home page).

The designed website uses several programs written in different programming languages. These programs work in an integrated fashion to accomplish the required task of disseminating the air quality information to general public. The programming languages used to develop the programs include Java, PERL, JavaScript and HTML. The actual implementation of the overall scheme (flowchart: Fig. 2) is presented as follows.

- The website has a clickable map of India from which

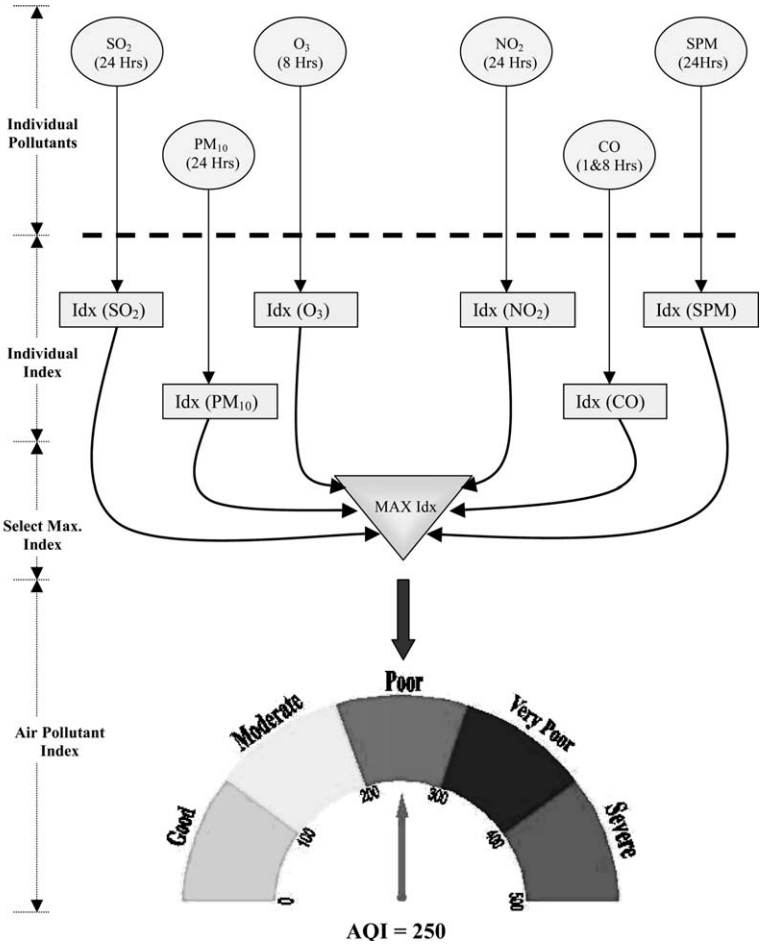

Fig. 1. Overall AQI calculation system.

Table 1
Linear segmented relationship for sub-index and pollutant concentration

Sub-index	Pollutant					
	SO_2 (μg/m³) 24-h avg.	NO_x (μg/m³) 24-h avg.	SPM (μg/m³) 24-h avg.	PM_{10} (μg/m³) 24-h avg.	CO (mg/m³) 8-h avg.	O_3 (μg/m³) 8-h avg.
0–100	0–80	0–80	0–200	0–100	0–2	0–157
101–200	81–367	81–180	201–300	101–150	2.1–12	158–235
201–300	368–786	181–564	301–700	151–350	12.1–17	236–784
301–400	787–1572	565–1272	701–840	351–420	17.1–35	785–980
401–500	>1572	>1272	>840	>420	>35	>980

the user can select a particular state. To make the map clickable, along the boundary of each state in the map (image), a polygon is defined. These polygons specify the area of states on the map. Each polygonal area represents a uniform resource locator (URL). The user can click within these polygonal regions to access the HTML file corresponding to that state (Fig. 3).

- For each state, a separate HTML file was made. The HTML file shows the name of cities with glowing mark for the cities in the state having information on air quality. To make the cities clickable, polygons are defined for each city. The user can select these cities by simply clicking on the glowing marks.
- On clicking at the city, an HTML document containing a 'form' through which the user can specify a location, date, month and year is opened. The user can select the location (within the city), date, month and year of interest for getting AQI (for example, see Fig. 4 showing the city of Mumbai along with 'form').

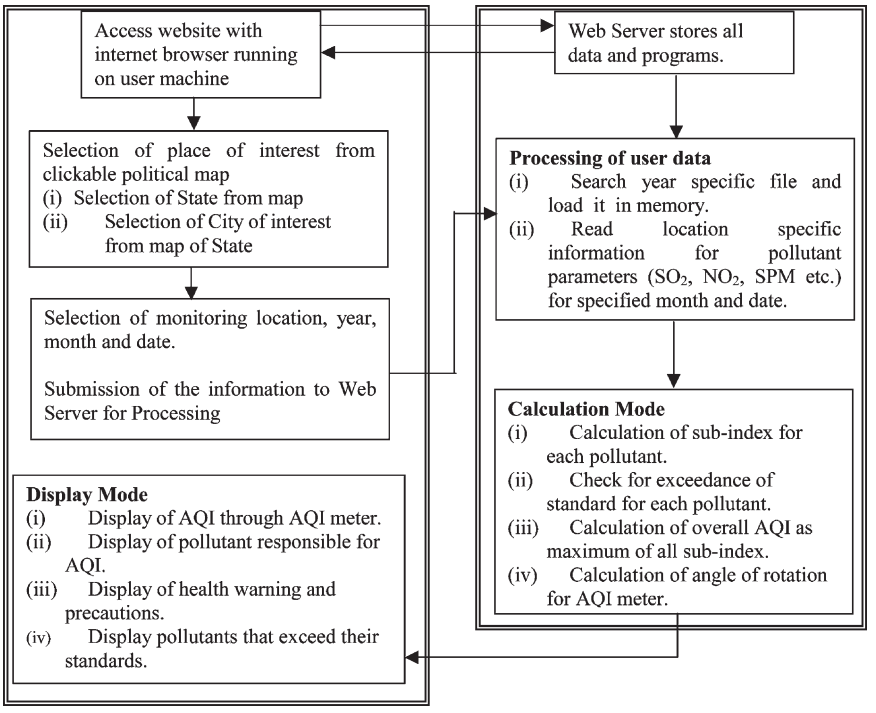

Fig. 2. Flowchart for design of website.

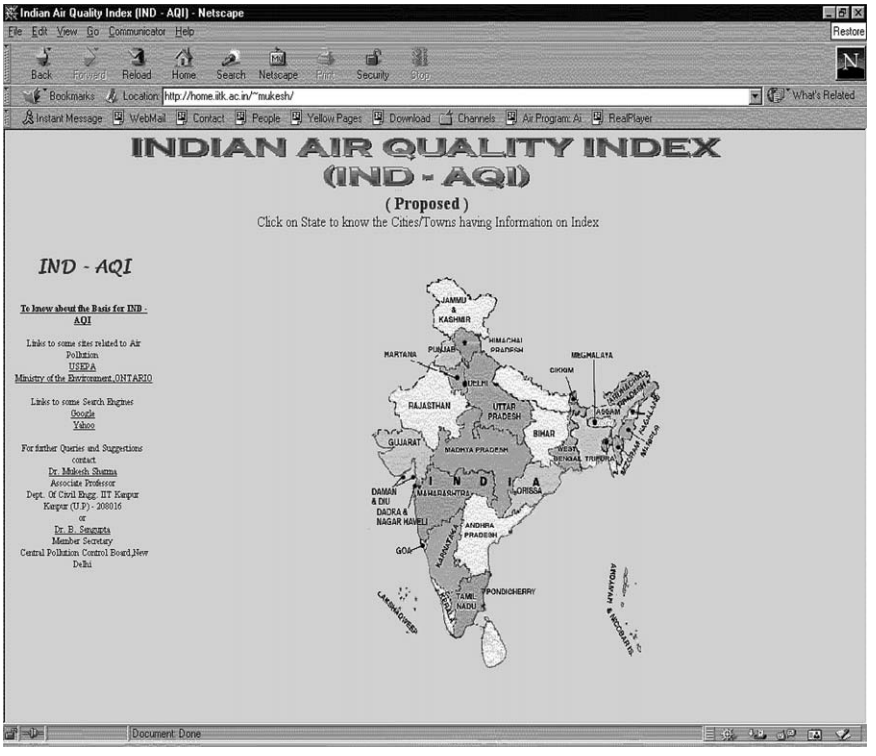

Fig. 3. Homepage of the website.

- After the user selects the required information through the form, the selected information is transferred to a program through common gateway interface (CGI) to server where this program is executed. All air quality data are stored on server through year-wise files. These files are simple text files. The fields in the file are 'tab- separated'. These files can be easily edited and created in MS Excel. The format of one such file is shown in Fig. 5.

In Fig. 5, location code represents code assigned to

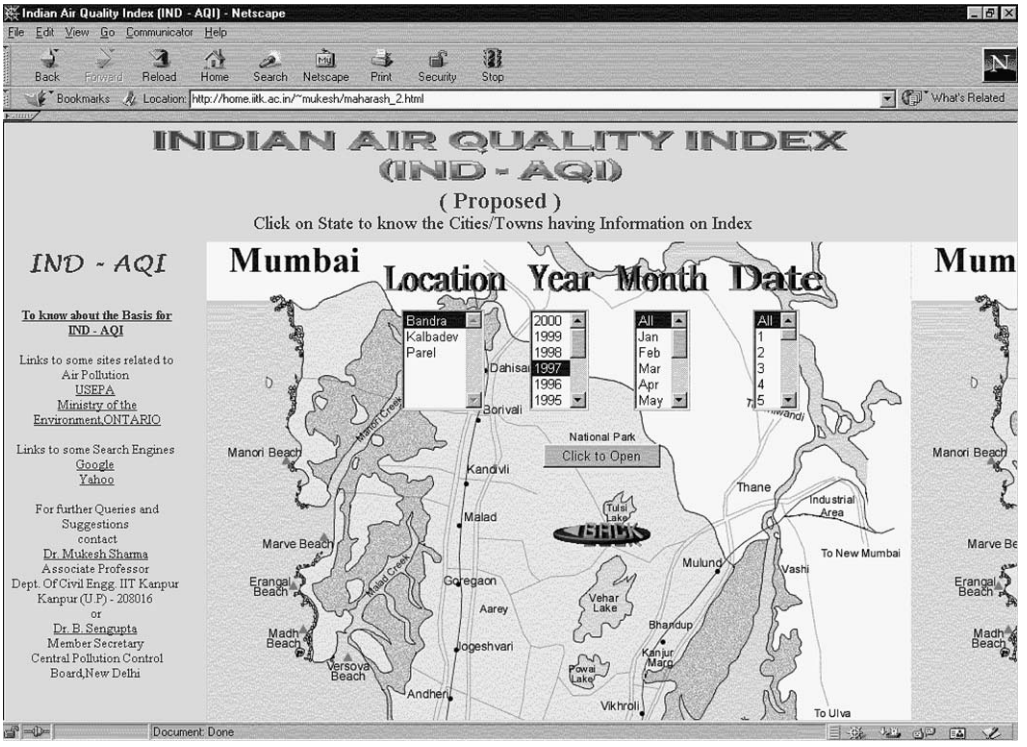

Fig. 4. HTML form for air quality location, year, month and date.

				Format of Data files								
Location Code	Location Type	City	State	Month	Date	Year	SO2	NOx	SPM	PM10	CO	O3
1	S	AGR	UTP	1	13	97	19.8	17.8	671	350	-1	-1
1	S	AGR	UTP	1	14	97	22	19.7	778	400	-1	-1
168	R	BOM	MAH	5	29	97	6	26.6	405	-1	-1	-1
168	R	BOM	MAH	6	4	97	7.5	8.8	196	-1	-1	-1
225	I	GZB	UTP	12	19	97	36	53	590	300	-1	-1
225	I	GZB	UTP	12	22	97	47	47	412	250	-1	-1

Fig. 5. Format of data file (data in $\mu g/m^3$).

each location. These codes are used to map location name in HTML files with location codes in data file. Location type indicates whether the location is categorized as sensitive (S), residential (R) or industrial (I). City names and state names are abbreviated. Value (−1) represents that data are not available.

The program uses the value of year provided by the user to select the specific file for that year and then it picks up the concentration data of pollutants from the file according to the date, month and location selected by the user. The program calculates sub-index for each pollutant and by using maximum operator method, it reports the maximum sub-index value as overall AQI (Fig. 1). According to the obtained values of sub-index of each pollutant, it also finds out which pollutant is exceeding its ambient air quality standard and which pollutant is responsible for pollution index value. According to the index value, program also gives health impacts. This program generates an HTML file that displays all this information in the browser (Fig. 6).

The range of IND-AQI has been classified into five categories and each category is specified a color as shown below.

Index value	Category	Color
0–100	Good	Green
101–200	Moderate	Yellow
201–300	Poor	Cyan
301–400	Very poor	Blue
401–500 or more	Severe	Red

For disseminating the air quality information to general public in form of colors, an animated meter-display is

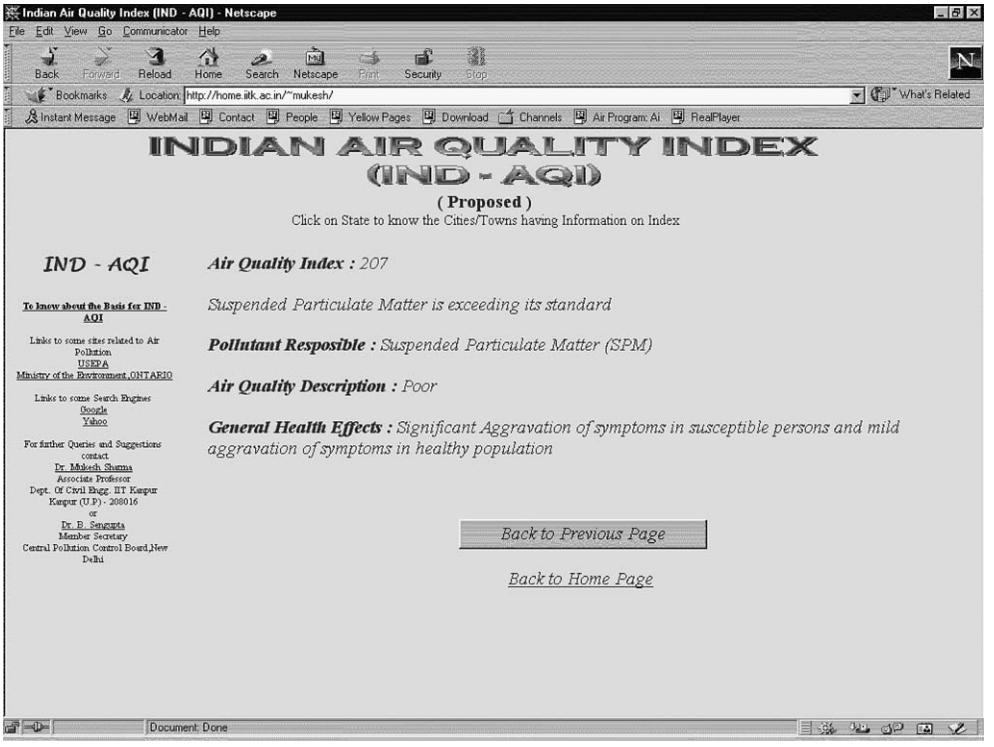

Fig. 6. Index value and category, exceedence of standard and general health effects.

developed. According to the value of index, there is a pointer that moves on a semi-circular scale to indicate category and color corresponding to index value (Fig. 7).

This meter-display is implemented using Java Applet and JavaScript. The input parameter passed to this applet program is angle of rotation by which the pointer has to move. This angle is calculated by the program running on the server. According to the calculated index value, the program invokes Java Applet program with required input parameter. The equation used to calculate the angle is

$$\text{Angle of rotation} = \text{Index value} \times 0.36.$$

The scale is semi-circle in shape so the pointer has to move from 0 to 180° to completely cover this semi-circle. On this semi-circle, five categories are shown with different colors and index value ranging from 0 to 500. Through each category, the pointer has to move by $180/5 = 36°$ (Fig. 7).

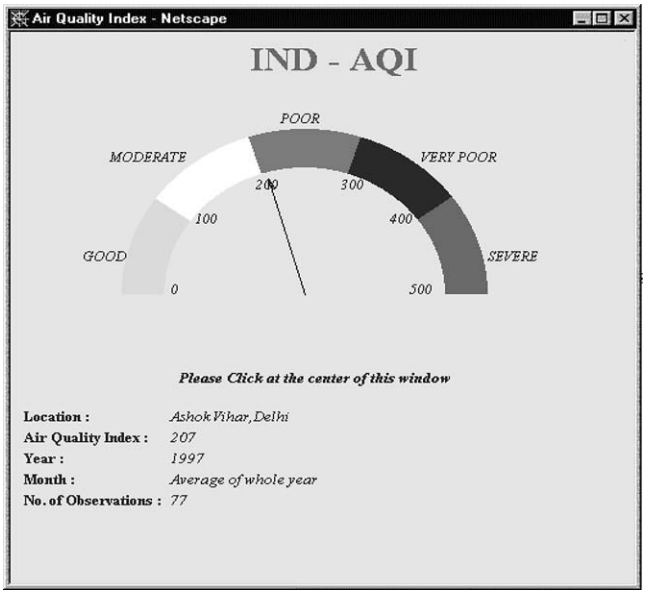

Fig. 7. Animated display of AQI.

5. Features of the website

The various features of this website are:

- AQI can be calculated for past 10 year and current data.
- Real-time AQI can be made available just by entering actual concentration of pollutants in files.
- This site can be used with automatic monitoring stations such that data generated can straight away be sent to server and added to files.
- If AQI is forecasted, it can be displayed.
- Comparison can be made between AQI on different dates.
- Comparison of AQI between different locations within same city can be made using multiple windows.

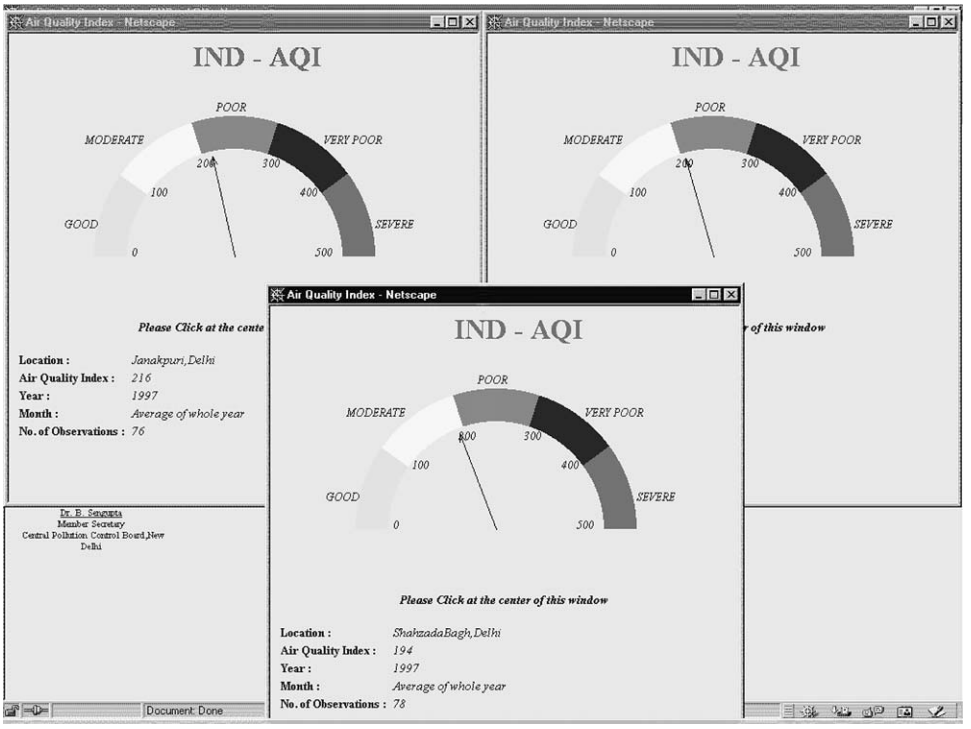

Fig. 8. Comparison of IND-AQI using multiple windows.

- Average AQI of entire month and year can be calculated.
- Display also provides number of data points used for calculations of index for monthly and yearly averages.
- Displays which pollutants are considered in calculation of AQI.
- Displays all pollutants which exceeds air quality standards.

One can also compare AQI (current as well as historical) of different locations within a city or different cities. For this, minimize the smaller window and either click the button to go back to the page of same city or click on the link to go back to first page and then select a new city from the map (of India) and follow the above procedure. The multiple windows will look as shown in Fig. 8.

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