The development and implementation of a database driven web-enabled integrated system for air quality observation and analysis

R. Rorich¹ & D. Sakulski²

¹Technology Services International (TSI), a Division of ESKOM Enterprises - South Africa
²MANIR South Africa c.c., South Africa

Abstract

Environmental Technologies, a section of Technology Services International (TSI), a division of Eskom Enterprises, has been undertaking investigative ambient air quality monitoring on behalf of Eskom Research Division, the major power utility in Africa, and other industry, since the late 1970s.

Presently, TSI is managing eighteen continuous air quality monitoring stations, generating strategic information comprising air pollution and meteorological parameters for various organisations. In addition, there are 45 discontinued sites from locations in a number of provinces where monitoring was undertaken for up to eight years.

Pollutants such as SO₂, NO, NO₂, O₃, FPM, wind direction, wind velocity and ambient temperature have been continuously monitored at these sites, and the hourly mean together with the highest and lowest readings during the hour recorded.

This has resulted in a vast database that has primarily been used by TSI to generate hard copy reports for the various organisations. To a large extent, this valuable archive of information is not readily accessible to environmental managers within the organisations, nor to scientists and researchers from other institutions. It is felt that this information could be of great value for Environmental Impact Assessments and Environmental Management Planning on a local and regional scale.
1 Objective

Eskom Research is continuously devising methods of improving the analysis techniques of air quality data and the dissemination of these results. It is felt that by utilising the latest available Internet web technology, the results of these analyses will be more widely available in formats suitable to a larger customer base.

The objective of this project is to facilitate user-friendly Internet applications for the statistical analysis of air quality data and the dissemination of results to a broad spectrum of customers via the Internet.

This will allow easy access to valuable information for environmental evaluation and planning.

2 Approach

The basic idea behind this project was to design, develop and implement a database driven, web-enabled interactive air quality data management system. A relational database had to be created to host the data, allowing restricted access to approved clients only.

Modules had to be written to facilitate the interpretation and statistical manipulation of this data as well as the presentation of tables and graphs.

Wind and pollution roses, time series graphs, histograms and pollution trends from the extensive regional monitoring network will be generated on request.

3 IT components

3.1 Hardware

At present, system functionality has been enabled using the following hardware components:

- PC based server
- Intel Pentium 650 MHz processor
- 256 MB RAM
- Ultra fast SCSI disc storage system

3.2 Software

Web service is run using MS NT Internet Information Server (MS IIS) on a Windows 2000 operating system. At present, data have been stored in MS Access 2000. The Pollution measurement table presently contains approximately 12 million records. TSI has been closely monitoring the speed and response time of the Access database.
In the near future, it is intended to migrate from Access to a SQL Server or ORACLE relational database management system.

Because MS IIS is run as a web service, ASP is used as a scripting language to connect to all components (database, analytical software, graphics). It accesses the database sending appropriate SQL requests, using an ODBC connection.

Results of the SQL request are embedded into an ASP script, to be presented as an alphanumeric report, as well as to be used as an input for the mathematical and statistical calculations and analysis.

A Linux version is being developed in parallel to the existing system. It will run on the same hardware, using Apache web server, MySql relational database and PHP as a scripting language.

4 Analytical capabilities

Analysis of the air quality data is based on standard mathematical and statistical procedures for the calculation of the parameters, such are:

- Mean, Median
- Standard Deviation
- Trend analysis
- Time series analysis
- Filtering techniques
- Visualisation (graphs, animations), etc.

All further requirements for the calculation of specific air quality results, or statistical parameters, models (algorithm or formulas) will be supplied by TSI.

5 Application step-by-step

Example page 1: User Login and password

To fulfil all proprietary rights of ESKOM, access to this web-based application has been granted to the approved clients, only. Typing an appropriate login and password will grant user access to the rest of the applications.

Example page 2: Main menu

At present, the following options are available on the menu page:

- Data for particular hour and date
- Largest / smallest hourly / daily mean for stipulated period
- Hourly / daily mean for stipulated period (graph)
- Exceedance of the stipulated hourly / daily level
- Moving average for hourly / daily data – Trend
Air Quality Management System (Demo)

**MENU** (O3 and SO2)

- Data for particular hour and date
- Largest/smallest hourly/daily mean for stipulated period
- Hourly mean for stipulated period (graph)
- Daily mean for stipulated period (graph)
- Exceedance of the stipulated hourly level(s)
- Exceedance of the stipulated daily level(s)
- Moving average (hourly data) - Trend
- Moving average (daily data) - Trend
- Raw data (hourly means)

Example page 3: Hour and date selection

![Interval Data Selection](image)

From

<table>
<thead>
<tr>
<th>Hour</th>
<th>Day</th>
<th>Month</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>January 1990</td>
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</tr>
<tr>
<td>6</td>
<td>6</td>
<td>June 1995</td>
<td>1995</td>
</tr>
</tbody>
</table>

Till

<table>
<thead>
<tr>
<th>Hour</th>
<th>Day</th>
<th>Month</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
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<td>June 1994</td>
<td>1994</td>
</tr>
</tbody>
</table>

Reset  SELECT
Example page 4: Interval selection query result

Air Quality Management System

Result of the Interval Data Selection from 5 hour(s) on 4/1/94 till 6 hour(s) on 5/6/94

<table>
<thead>
<tr>
<th></th>
<th>O₃</th>
<th></th>
<th></th>
<th>SO₂</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concentration [ppb]</td>
<td>Hour</td>
<td>Date [mm/dd/yy]</td>
<td>Concentration [ppb]</td>
<td>Hour</td>
</tr>
<tr>
<td>The largest hourly</td>
<td>70.3</td>
<td>18</td>
<td>4/26/1994</td>
<td>73.3</td>
<td>9</td>
</tr>
<tr>
<td>The smallest hourly</td>
<td>1.5</td>
<td>9</td>
<td>5/1/1994</td>
<td>0</td>
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</tr>
</tbody>
</table>

Example page 5: Daily means exceedance query result

Air Quality Management System

Daily Means Exceedance (15 ppb) from 1/1/90 till 2/4/90

<table>
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<tr>
<td>1/27/1990</td>
<td>22 675</td>
</tr>
<tr>
<td>2/1/1990</td>
<td>15 8604</td>
</tr>
</tbody>
</table>
Example page 6: Daily means for selected period - Graph

Air Quality Management System

Result of the Daily Means for the Period: 4 April '93 - 22 May '93
Interval's statistics: Max=21.04  Min=1.25  Mean=6.83

Example page 7: SO₂ trend analysis

Air Quality Management System

Daily Means Trend: 1 Jan 1990 - 30 Jun 1993

SO₂ Daily Means Trend (Moving Average 365 days)
6 Next steps?

At present, additional user requirements are being assessed. It will help the developer to build a broader, and more detailed picture of user needs. The next version (update) of the application will enable additional functions such as:

- Air quality modelling
- Time series analysis
- Animation and visualisation
- GIS capability

7 Acknowledgement

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References

