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A Visualization Approach of Air Quality Index using R Review Paper

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Abstract: A visualization approach of Air quality Index using R is a tool for identifying the present scenario of air quality. Five different methods of estimating Air quality Index (AQI) based on four pollutants synergistic effect viz., RSPM, PM10, PM2.5, SO2 and NO2 were used to compare the prevailing ambient air quality in the study region. Seasonal and daily AQI calculation revealed that air quality status in the study region under various classes ranging from good moderate, satisfactory and unacceptable class for different AQI calculation.

Keywords: Visualization; air pollution; Air Quality index; PM2.5; PM10; SO2, NO2;RSPM; visual exploration; spatio-temporal data analysis; R language; Openair packages.

I. INTRODUCTION

The concept of an Air Quality Index (AQI) has been developed and used effectively in many developed countries for over last three decades (USEPA 1976, 2014; Ontario, 2013; Shenfeld, 1970). An AQI is defined as an overall scheme that transforms weighted values of individual air pollution related parameters (SO₂, CO, visibility, etc.) into a single number or set of numbers. The challenge of communicating with the people in a comprehensible manner has two dimensions: translate the complex scientific and medical information into simple and precise knowledge and communicate with the citizens in the historical, current and futuristic sense.

Globally, many cities continuously assess air quality using monitoring networks designed to measure and record air pollutant concentrations at several points deemed to represent exposure of the population to these pollutants. Current research indicates that guidelines of recommended pollution values cannot be regarded as threshold values below which a zero adverse response may be expected. Therefore, the simplistic comparison of observed values against guidelines may mislead unless suitably quantified. In recent years, air quality information are provided by governments to the public comes in a number of forms like annual reports, environment reviews, and site or subject specific analyses/report. These are generally having available or access to limited audiences and also require time, interest and necessary background to digest its contents. Presently, governments throughout the world have also started to use real-time access to sophisticated database management programs to provide their citizens with access to site-specific air quality index/air pollution index and its probable health consequences. Thus, more sophisticated tool has been developed to communicate the health risk of ambient concentrations using air pollution index (API) or air quality index (AQI).

A. Objectives

- 1) Government agencies to predict AQI, publicize in order to bring in awareness across messages.
- 2) Air purifier manufacturing industries to promote their products.
- 3) Alternatives
- 4) To provide environmentalists pollution data for further analysis.

B. Health Issues

The World Health Organization (WHO) estimates that 25% of all deaths in the developing world can be directly attributed to environmental factors (WHO, 2006). The problem of air pollution and its corresponding adverse health impacts have been aggravated due to increasing industrial and other developmental activities.

C. Responsible Pollutant For AQI

The analysis of AQI is based on maximum operator calculation mode, where the maximum sub-index value of pollutants becomes the overall index. It is observed that most of the time

SPM and PM10 are the responsible pollutant for high AQI value. Thus, to improve the air quality of U.P. and other states PM2.5 is also responsible so concentration of SPM and PM10 PM2.5 have to be reduced on priority basis.

D. Awareness Program

In India, CPCB implements the National Ambient Air Quality Monitoring (NAMP) through a Network comprising 544 operating ambient air quality stations covering 224 cities / towns in 26 States and 5 Union territories of the country in compliance with the mandate under the Air (Prevention and Control of Pollution) Act, 1981 to collect compile and disseminate the information on ambient air quality. The air quality monitoring network in India can be classified as (i) online and (ii) manual. The pollutant parameters, frequency of measurement and monitoring methodologies for two networks are very different.

II. VISUALIZATION

This study proposed an efficient visualization method to represent directly, quickly, and clearly the spatio-temporal information contained in air pollution data. Data quality check and cleansing during a preliminary visual analysis is presented in tabular form, heat matrix, or line chart, graphs and ggplots upon which hypotheses can be deduced. Further visualizations were designed to verify the hypotheses and obtain useful findings.

III. OPENAIR PACKAGES

Openair is an R package primarily developed for the analysis of air pollution measurement data but which is also of more general use in the atmospheric sciences. The package consists of many tools for importing and manipulating data, an undertaking a with range of analyses to enhance understanding of air pollution data. In this paper we consider the development of the package with the purpose of showing how air pollution data can be analysed in more insightful ways. Examples are provided of importing data from Indian air pollution networks, source identification and characterisation using vicariate polar plots, quantitative trend estimates and the use of functions for model evaluation purposes. We demonstrate how air pollution data can be analysed quickly and exigently and in an interactive way, freeing time to consider the problem at hand. One of the central themes of openair is the use of conditioning plots and analyses, which greatly enhance inference possibilities.

A. Other Tools Used For Air Quality Monitoring

- 1) *Indoor Air Quality Monitoring Tool using Wireless Sensor Network:* A wireless solution for indoor air quality monitoring has been developed. The developed solution is to measure the environmental parameters like temperature, humidity, gaseous pollutants, Particulate Matter to determine the environmental health of an indoor space. Air Quality Index (AQI) as per EPA standard is estimated from the measured indoor criteria air pollutants. A toolkit has been developed to view the live air quality data of deployed regions in the form of numbers and graphs.
 - a) Wireless monitoring of environmental parameters through Zigbee
 - b) Live monitoring of air pollution data through IAQ tool kit
 - c) Air Quality index estimation as per EPA standard
- 2) *Environmental Monitoring Systems And Instruments For Outdoor Air Quality Testing:* We help people, companies and governments make better air quality decisions by providing them with cost effective and reliable instrumentation and information. Our sensor-based instruments and environmental monitoring systems are used widely in outdoor ambient applications for compliance, non compliance and special purpose monitoring.
- 3) *Ozone Sensors And Instruments For The Measurement And Control Of Ozone In Air:* Our ozone sensors and monitoring systems are used in a wide range of ozone monitoring and control applications. Gas sensitive semiconductor technology allows ppb level detection with high accuracy and stability at a fraction of the cost of analyzer based instruments.

B. Air Monitoring Software's

Air monitoring software comes standard when you purchase an Aeroqual instrument, such as the AQM 65, AQS 1, AQY 1, Dust Sentry or Dust Profiler. Accessed through a custom-built software interface, the software gives you and other trusted users secure access to air quality data in real-time. It also enables engineers to provide remote technical support and servicing. The software is browser based so there's nothing to install – simply connect your computer, tablet or phone, open your browser and away you go.

- 1) Aeroqual Connect is the instrument operating software located on the embedded PC in the instrument.
- 2) Aeroqual Cloud gives you and other trusted users access to all of your instruments via secure third party servers.

IV. LITERATURE REVIEW

A. Review of Air Quality Indices (AQI)

The large databases often do not convey the air quality status to the scientific community, government officials, policy makers, and in particular to the general public in a simple and straightforward manner. This problem is addressed by determining the Air Quality Index (AQI) of a given area. AQI, which is also known as Air Pollution Index (API) (Murena, 2004[6]; Ott and Thom, 1976[8]; Thom and Ott, 1976; Shenfeld, 1970) or Pollutant Standards Index (PSI) (U.S. EPA, 1994; Ott and Hunt, 1976[9]), was developed by various environmental mental agencies/researchers for different country/regions. Though, there is a widespread use of air pollution(quality) index systems but currently no internationally accepted methodology for constructing such a system (Stieb *et al.*, 2005; Maynard and Coster, 1999) are available. In this paper, an attempt has been done to demonstrate the critical review on different AQI systems.

B. Approaches to determine the Air Quality Indices (AQI)

AQI which is also known as air pollution index (API) [Shenfeld, 1970;[12] Ott and Thom,1976;[15] Thom and Ott, 1976;[15]Murena,2004[6]] or pollution standard index (PSI) (Ott and Hunt,1976[8];USEPA,1994) has been developed by many agencies in USA, Canada, Europe, Australia, China, Indonesia, Taiwan etc.(Cairncross et al,2007;Cheng et al,2007).

C. Common Air Quality Index (CAQI)

The CAQI was developed by the Cite air project in 2008, which was co-funded by the INTERREG IIIC and INTERREG IVC programs in Europe. To present the air quality situation in European cities in a comparable and understandable way, all detailed measurements are transformed into a single relative figure called the Common Air Quality Index (CAQI). An important feature of this index system is that it differentiate between traffic and city background conditions. The Common Air Quality Index (CAQI) is designed to present and compare air quality in near-real time on an hourly or daily basis. It has 5 levels, using a scale from 0 (very low) to >100 (very high) and the matching colours range from light green to dark red. The CAQI is computed according to the grid system by linear interpolation between the class borders. The final index is the highest value of the sub indices for each component (pollutant); nevertheless, the choice of the classes for the CAQI is inspired by the EC legislation. The CAQI do not take into account the adverse effects due to the coexistence of all the pollutants. The existing air quality indices were used by van den Murena, F., *at al*(2004).[6] for air quality assessment in European cities. They compared all the existing method for identification of suitable alternative.

D. ONTARIO API

Shenfeld (1970)[12] developed Ontario Air Pollution Index in Canada. This index was intended to provide the public with daily information about air quality levels and to trigger control actions during air pollution episodes. It includes two pollutants variables: $API = 0.2 (30.5 COH + 126 SO_2) 1.35$ Both COH and SO₂ (in ppm) are 24 hour running averages

E. OAK Ridge Air Quality Index

Oak Ridge National Laboratory published the ORAQI in 1971 (Thom and Ott)[15] . It was based on the 24-hour average concentrations of the following five pollutants: 1. SO₂ 2. NO₂ 3. PM₁₀ 4. CO 5. Photochemical Oxidants The sub-index is calculated as the ratio of the observed pollutant concentration to its respective standard. As reported by Babcock and Nagda (1972), the ORAQI aggregation function was a non-linear function:

$$ORAQI = \{5.7 \sum I_i\}^{1.37}$$

where,

$$I_i = (X/X_s)_i$$

X = Observed pollutant concentration

X_s = Pollutant Standard I = Pollutant

The above method can be applied to assess the air quality in urban area without facilitating or considering the spatial aggregation, and uncertainty measures but considers pollutant aggregation and health effects.

F. Air Quality Depreciation Index

The air quality depreciation index (Sharma et al[11]) attempts to measure deterioration in air quality on an arbitrary scale that ranges between 0 and -10. An index value of '0' represents most desirable air quality having no depreciation from the best possible air quality with respect to the pollutants under consideration while an index value of -10 represents maximum depreciation or worst air

quality. The reduction in index values ranging from 0 to -10 represents the successive depreciation in air quality from the most desirable. The air quality depreciation index is calculated as follows:

$$AQ_{dep} = \sum_{i=1}^n (AQ_i * CW_i) - \sum_{i=1}^n CW_i$$

(1)

Where, AQ_{dep} = Air quality depreciation index AQ_i = Air quality index value for ith parameter CW_i = Composite weight for ith parameter n = Total no. of pollutants considered The values of the AQ_i were obtained from the value function curves. In the value function curves the value of 0 signifies worst air quality and value of 1 represents the best air quality for corresponding pollutant concentration. The value of CW_i in equation (1) is computed using the following expression:

$$CW_i = \frac{TW_i}{\sum_{i=1}^n TW_i} * 10$$

(2)

Where,

TW_i = Total weight of ith parameter

TW_i = A_i + BPIW_i + HW_i (3)

Where, A_i = Aesthetic weight for it parameter

BPIW_i = Bio- Physical Impact Weight for ith parameter

G. Fuzzy Air Quality Index

Mandal *et al.* (2012)[7] developed a method for prediction of AQI on the basis of fuzzy aggregation. The output AQI value using fuzzy aggregation method was compared to that of the output from conventional method. It was demonstrated that computing with linguistic terms using fuzzy inference system improves tolerance for impression data. The relationship between air pollutants and output parameter (FAQI) is mathematically expressed as given in the eqn.

$FAQI = f(PM10, PM2.5, RSPM, SO2, NO2)$

Gorai *et al.* (2014)[7] developed a fuzzy pattern recognition model for AQI determination. The method was used for air quality assessment of Agra city. This method considered five air pollutants (PM10, CO, SO2, NO2, and O3) for AQI determination. The method also considers weights of the individual pollutants on the basis of its degree of health impacts during aggregation.

Analytical hierarchical process (AHP) was used for determination of weights of various pollutants. The air quality index is ranged from 1 to 6. The higher is the value of AQI, higher is the health risk and vice versa. Authors suggested that depending upon the risk level, air quality mangers can take preventive measures for reducing the level of index. Though, the formula or method used for determination AQI is relatively complex in comparison to that of the arithmetic aggregation method but this can be easily programmed for determination of AQI.

H. New Air Quality Index

New air quality index is based on factor analysis of the major pollutants and is given by Bishoi *et. Al*[1] in 2009. The new air quality index (NAQI) is given by the equation

$NAQI = \{ \sum_{i=1}^n (P_i E_i) / \sum_{i=1}^n E_i \}$

Where n=3, P₁, P₂, P₃ are the three principal components for which the cumulative variance is more than 60%. E₁, E₂ and E₃ are the initial eigen values (> 1) with respect to the percentage variance The principal components were given by Lohani (1984)

$P_i = \sum_{j=1}^3 a_{ji} X_j / \lambda$

Where e_i is the eigen value associated with P_i If the X_j is used for pollutant concentration then

$X_j = \sum_{i=1}^3 a_{ji} P_i$

The method can be applied to assess the relative air quality without facilitating or considering the spatial aggregation, health effects and uncertainty measures but considers pollutant aggregation.

V. CONCLUSION

A visualization approach of Air quality Index using R is a tool for identify the present scenario of air quality. SO₂ and NO₂ are well within the NAAQ standards for 24 hours. The higher value of PM₁₀ is mainly due to vehicular pollution. Vehicular emissions are of particular concern because these are ground level sources and thus have the maximum impact on general population. Also, vehicles contribute significantly to the total air pollution load in many urban areas [8-10]. It is to be noted that AQI system is based on maximum operator function by selecting the maximum of sub-indices of various pollutants as overall AQI. Ideally, five parameters (i.e.,) PM₁₀, PM_{2.5}, NO₂, SO₂, RSPM having short-term standards should be considered for near real-time dissemination of AQI. In case AQI category is severe or very poor, necessary steps need to be taken by further regulating the emissions which are causing maximum impact to ambient air quality. Specific actions, such as (i) strict vigilance and no-tolerance to visible polluting vehicles, industries, open burning, construction activities etc.; (ii) regulating traffic; and (iii) identifying sources contributing significantly to rising air quality levels and actions for reducing emissions from such sources are to be taken.

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