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Online Detection and Analysis System for Air Pollution Hot Spots in Turkey

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Abstract. Air pollution is one of the important worldwide environmental problems that cause harmful effects on human health, property, aesthetics and the global climate. This makes air quality management necessary and developing efficient and systematic analysis methods for air pollution simplify the decision-making and production of solutions to this problem. In Turkey, Ministry of Environment and Urbanization has national air quality monitoring network contains 122 stations all over the country, measurement results are obtained from the monitoring network and published hourly, this is a pure data and needed to be processed. In this study, a fully automated data collection method was developed; collected data were analyzed spatially and temporally. Hot spots of air pollution were detected. Analysis results were discussed; possible reasons of the problem and suggestions were mentioned. A systematic data collection and analysis approach were developed.

Keywords: Air pollution, Turkey, Hot spots, Spatial, Temporal, Data analysis

1. Introduction

The Earth we live in, the air we breathe has never become clean and air pollution has always become a phenomenon throughout the human history. [1] Air pollution is an inevitable consequence of modern life. However, if this resultant problem reaches to the highest points, it can cause both regional and global changes, these worldwide problems can be a serious threat for the future of the Earth. This makes air quality management necessary in both global and local scales. Air quality management has three components, which are measurements, policy-making and producing best available control methods. Air quality monitoring systems provide us to measure the defined air pollutant parameters and the measurement results provide us to analyze, to model, to regulate air pollution and to produce solutions. U.S EPA, E.U. and many other national environmental agencies have set of standards and air quality guidelines for allowable levels. [6] In Turkey, Ministry of Environment and Urbanization is the competent authority on this issue. Ministry has national air quality monitoring network contains 122 measurement stations in 81 cities of the country. Air quality parameters, which are particulate matter (PM_{10}) and gaseous pollutants (CO, SO_2, NO, NO_2, NO_X, O_3), are measured and the measurement results are displayed on the Ministry's air quality monitoring network website, the results are hourly updated on this website. However, these are pure datasets and don't mean anything in terms of air quality management. Raw air quality data must be collected and analyzed in a systematic way.

Computer systems are inevitable tool in today's world and computer systems can be integrated into every field of life and it makes the problem solving easier than before. In environmental management, computer softwares are important tools to manage the data and simplify the decision-making.

The main purpose of this study is to analyze and process air quality measurement datasets and to develop an early warning system. This fully automated system will simplify the decision-making procedures. The

overall goal of this system is to automate data collection, processing and evaluation in order to develop warning system for decision makers.

2. Methodology

2.1. Study Area

Turkey is a country that has a strategic importance in the world due to its geopolitical location as it is on the crossroads between the continents of Asia, Europe and Africa. Turkey is located in the temperate zone between the 36 and 42nd degrees of northern latitudes and 26 and 45th degrees of eastern longitudes. The estimated population of the country in 2011 is 74,724,269. Turkey is divided into seven geographical regions in terms of natural, demographic and economical aspects. These regions are: The East Anatolia Region (21% of the surface area), The Central Anatolia Region (20% of the surface area), The Black Sea Region (18% of the surface area), The Mediterranean Region (15% of the surface area), The Aegean Region (10% of the surface area), The Marmara Region (8.5% of the surface area) and The Southeast Anatolia Region (7.5% of the surface area).

Air quality monitoring network, which is owned and operated by Turkish Ministry of Environment and Urbanization, contains 122 stations. Stations are shown on the Figure 1.1. 7 Air quality parameters measured hourly are PM_{10}, CO, SO_2, NO, NO_2, NO_X, O_3 together with the meteorological data.

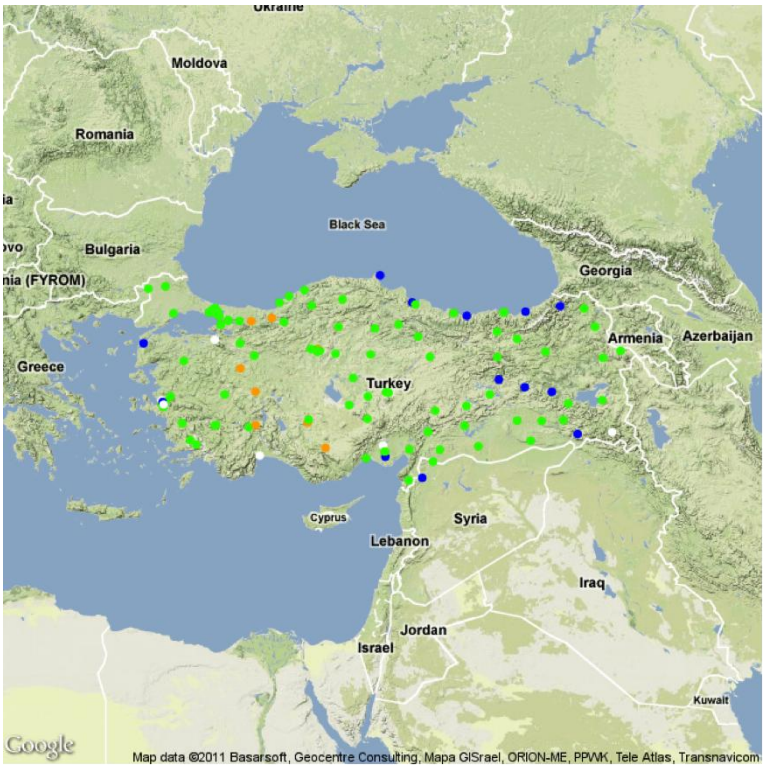

Fig. 1. 1: Study Area

2.2. Data Collection

Ministry's air quality monitoring network publishes hourly raw measurement data on a website (*http://www.havaizleme.gov.tr*). In order to achieve our goals, this data must be collected in an efficient and systematic way and must be stored effectively in a designed database. Data collection must also be performed in an automated way. The system architecture of data gathering/evaluation/warning is given in the figure 2.1. R programming language and MySQL relational database management system is selected for this task on Ubuntu OS installed machine.

The data collection was started on 1st January 2012. Therefore, in the analysis part, the data from January to May is used.

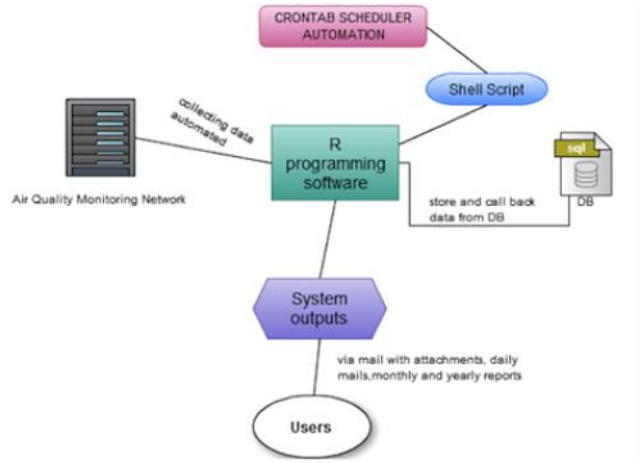

Fig. 2. 1: System Architecture

The system workflow, shown in figure 2.1, has an automated data collection mechanism. Crontab, task scheduler on Linux-based systems, executes code script, developed with the R programming language, hourly. The R code gathers the HTML file, processes and inserts it onto the designed database. Figure 2.2. is the screenshot from the system after data collection.

tstep	stationID	parameterID	value
2011-11-30 00:00:00	605	2	206
2011-11-30 00:00:00	605	3	38
2011-11-30 00:00:00	605	6	0.4
2011-11-30 00:00:00	605	7	70
2011-11-30 00:00:00	605	8	1008
2011-11-30 00:00:00	485	2	75
2011-11-30 00:00:00	485	3	41
2011-11-30 00:00:00	485	6	0.8
2011-11-30 00:00:00	485	7	51.3
2011-11-30 00:00:00	485	8	952
2011-11-30 00:00:00	488	3	51
2011-11-30 00:00:00	488	4	63
2011-11-30 00:00:00	488	5	153
2011-11-30 00:00:00	489	2	31

Fig. 2. 2: Data collection snapshot

2.3. Data Analysis

Collected raw data must be processed before they are analysed. Data analysis phase has crucial importance. Developing systematic analysis methodology for air quality data is a challenging process. System's main aim is to return the valuable results with the raw air quality data. Data analysis divided into two parts, firstly spatial analysis and secondly temporal analysis with the collected data.

Stations that have highest PM_{10} concentrations in each region are detected. Detailed analysis methodology for these hot spots is performed. Time series analysis is performed, for the data from January to May 2012. The recent air quality profile is shown; time series plots are the outputs of the system. The outputs will be evaluated and discussed with considering both E.U.'s and Turkey's air pollution limit values.

3. Results& Discussion

In the data analysis part, the analysis methods are generally mentioned. While evaluating the air quality data, E.U.'s limit concentrations are considered. PM_{10} limit value is 50 $\mu g/m^3$. Hot spots of air pollution in the country are determined according to the PM_{10} parameter.

Afyon, Duzce, Hakkari, Isparta, Karaman, Sakarya and Siirt are the air pollution hotspots in the 4-month period, from January to May 2012. Afyon's daily PM_{10} mean is 135 $\mu g/m^3$ and daily max concentration of the city is 352 $\mu g/m^3$; the hourly maximum concentration is 545 $\mu g/m^3$. Isparta's daily mean is 107 $\mu g/m^3$; the hourly maximum concentration detected by the system is 1151 $\mu g/m^3$. The cumulative distribution of

Afyon and Isparta stations is given in the figure 2.3. This figure shows the distribution of PM_{10} concentration over 4-month time period.

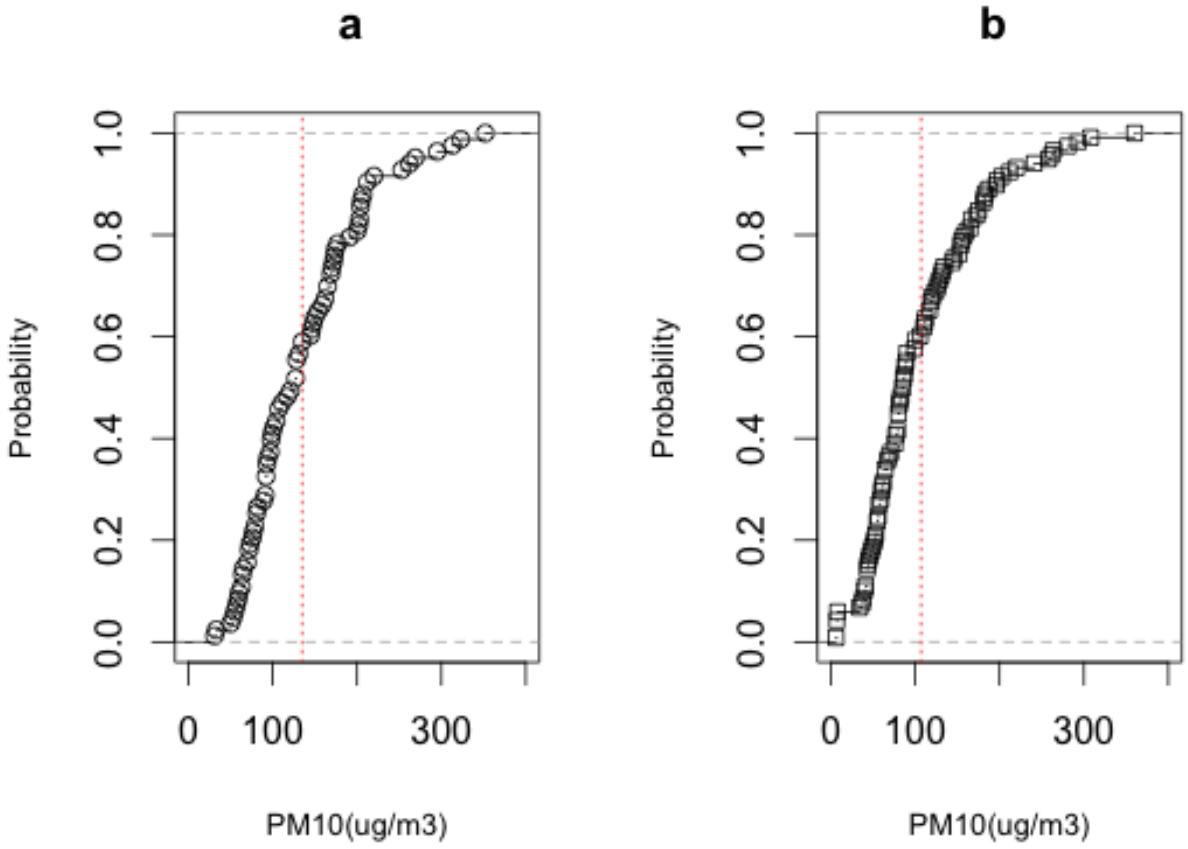

Fig. 2. 3: (a) Cumulative distribution of PM_{10} concentration in Afyon. (b) Cumulative distribution of PM_{10} in Isparta.

The vertical dashed lines show the mean concentration for each station. Median for Afyon is 127 $\mu g/m^3$ and standard deviation is 69. Median for Isparta is 86 $\mu g/m^3$ and standard deviation is 70.

This warning system will simplify the decision-making by working integrated with the air quality monitoring network and it will be able to detect air pollution hotspots of the country.

4. Acknowledgements

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