HEALTH RISKS ZONATION IN MEGACITIES VIS-À-VIS PM USING GIS-BASED MODEL

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ABSTRACT

In megacities, exposure to high concentrations of air pollution, as a major concern on public health, is being felt worldwide problem. The issue of particulate matter especially the PM$_{2.5}$ has become extremely crucial in Tehran, due to industrialization and population growth. Therefore, it is crucial to estimate the PM$_{2.5}$ concentrations for the purpose of health risk evaluation. Since the air quality, considering PM$_{2.5}$ varies over space and time, in this paper, RBF method in a based GIS model was utilized to zone air quality and its health risks upon PM$_{2.5}$ concentrations dispersion over Tehran, during one year, from 21 March 2013 to 20 March 2014. The RBF method was applied to obtain the zoning maps and determine the highest concentration of PM$_{2.5}$ in the 22 Tehran’s regions for each season. The RMSE$_{\text{min}}$ values according to the types of functions in the RBF method, viz.: Completely regularized spline, Spline with tension, Multiquadric function, Inverse multiquadric function, and Thin-plate spline, for each month have been assessed. The numbers of neighbors in the model for each function were varied from 3 to 15.

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The results indicate that the models with 4 neighbors have the best performance with the lowest RMSE values by using RBF method. In accordance with health risks assessment, the most and less favorable health conditions happen during spring and winter respectively. However, the most critical zone is city center.

**Keywords:** Air pollution; PM$_{2.5}$; Tehran; Health risks; GIS method; RBF model; Zonation; RMSE.

1. **INTRODUCTION**

In the past few years, the issue of particular matter (PM) had increasing negative impacts on human health and environment, owing to global urbanization and industrialization (Cogliani, 2001; Lee et al., 2011; Yadav et al., 2015; Liu and Cui, 2014). High concentrations of airborne particle in urban areas may precipitate respiratory problems, such as asthma and bronchitis, and also escalate likelihood of human lung cancer and cardiopulmonary mortalities (Pope III et al., 2002; Solomon et al., 2003; Houssaini et al., 2007; Kan et al., 2007; Neuberger et al., 2007; Babin et al., 2008). In contrast with the past, the air quality index with considering PM has exceeded the standard values at more regions in Tehran as an industrialized area. In Tehran, the coarse particles are mixture of various materials which may include metals, ions, minerals, organic content, PAH, soot, microorganism, etc. Further, the researches in the air pollution fields have indicated that an effective solution to spatial dispersion modeling of PM is the application and implementation of a geographic information system (GIS) in which measured data after analyzing can be used for obtaining the zoning maps (Cyrys et al., 2005; Gumusay et al., 2008; Salah et al., 2014; Tang et al., 2010; Vienneau et al., 2012).

In this research, to assess health risks zonation upon PM$_{2.5}$ and its spatial analysis over Tehran, monthly recorded PM$_{2.5}$ concentration datasets, during one year, from 21 March 2013 to 20 March 2014 have been collected. To normalize huge number of data, avoiding less effective values, the lag effects are filtered and the concentration data have been implemented on rush hour values upon weighted coefficient. To develop spatial dispersion maps of PM$_{2.5}$ over Tehran using RBF method, the authors used the monthly average concentration of PM$_{2.5}$. In addition, to develop air quality evaluation modeling and health risks zonation in Tehran, the authors used AQI calculator to determine levels of air quality with a significant color over Tehran vis-à-vis PM$_{2.5}$ concentrations.
2. CASE STUDY
In this study, the data set was collected from the urban air monitoring stations in Tehran. In figure 1, are shown the geographical map and air pollution monitoring stations over Tehran. The stations in Tehran’s regions are constantly monitoring air and report the daily data, which are used in this research such as PM$_{2.5}$ concentrations.

![Geographical map and air pollution monitoring stations of Tehran](image)

**Fig.1.** Geographical map and air pollution monitoring stations of Tehran

3. METHODS
Since the air pollution dispersion upon PM$_{2.5}$ concentrations varies over space and time, in this paper, RBF method in a based GIS model was utilized to zone PM$_{2.5}$ over Tehran, during one year, from 21 March 2013 to 20 March 2014. The RBF method was applied to obtain the zoning maps and determine the highest concentration of PM$_{2.5}$ in the 22 Tehran’s regions for each season. For obtaining health risks zonation maps, the AQI calculator was utilized, so it helps determine levels of health concerns over Tehran with a significant color.

4. RESULTS
In this research, the RMSE$_{min}$ values according to the number of neighbors and types of functions in the RBF method, such as CRS, SWT, MF, IMF, and TPS for each month have been assessed. Results of predicted RBF model predicted of PM$_{2.5}$ concentrations over Tehran in the spring and
winter and the $\text{RMSE}_{\text{min}}$ assessment with considering number of neighbors and types of functions, viz.: CRS, SWT, MF, IMF, and TPS are shown in Figure 2, 3 and table 1. Further, this study presents the health risks map based on AQI calculating in Spring and winter, for various Tehran's regions, in figure 4.

**Table 1.** Results of the total number of $\text{RMSE}_{\text{min}}$ with considering number of neighbors and type of functions, viz.: CRS, SWT, MF, IMF and TPS.

<table>
<thead>
<tr>
<th>Number of neighbors</th>
<th>CRS</th>
<th>SWT</th>
<th>MF</th>
<th>IMF</th>
<th>TPS</th>
<th>Total</th>
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<td>3</td>
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<td>2</td>
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<tr>
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<td>2</td>
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</tbody>
</table>
From 21 March 2013 to 20 April 2013 (AS)

From 22 December 2013 to 20 January 2014 (AW)

From 21 April 2013 to 21 May 2013 (BS)

From 21 January 2014 to 19 February 2014 (BW)

From 22 May 2013 to 21 June 2013 (CS)

From 20 February 2014 to 20 March 2014 (CW)
Fig. 2. Results of predicted RBF model vis-à-vis PM$_{2.5}$ concentrations over Tehran in the spring and winter. (AS) from 21 March 2013 to 20 April 2013, (BS) From 21 April 2013 to 21 May 2013, (CS) From 22 May 2013 to 21 June 2013, (AW) From 22 December 2013 to 20 January 2014, (BW) From 21 January 2014 to 19 February 2014, (CW) From 20 February 2014 to 20 March 2014
Fig. 3. Plots of the measured and predicted concentrations of PM$_{2.5}$ by using RBF, (AS) from 21 March 2013 to 20 April 2013, (BS) from 21 April 2013 to 21 May 2013, (CS) from 22 May

**Fig. 4.** Map of health risks zonation based on AQI in Spring and winter and the six levels of health concerns. (S) Spring: from 21 March 2013 to 21 June 2013, (W) Winter: from 22 December 2013 to 20 March 2014

<table>
<thead>
<tr>
<th>Air Quality Index</th>
<th>Levels of Health Concern</th>
<th>Colors</th>
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</thead>
<tbody>
<tr>
<td>0-50</td>
<td>Good</td>
<td>Green</td>
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<tr>
<td>51-100</td>
<td>Moderate</td>
<td>Yellow</td>
</tr>
<tr>
<td>101-150</td>
<td>Unhealthy for sensitive groups</td>
<td>Orange</td>
</tr>
<tr>
<td>151-200</td>
<td>Unhealthy</td>
<td>Red</td>
</tr>
<tr>
<td>201-300</td>
<td>Very unhealthy</td>
<td>Purple</td>
</tr>
<tr>
<td>301-500</td>
<td>Hazardous</td>
<td>Marron</td>
</tr>
</tbody>
</table>


**5. CONCLUSIONS**

In conclusion, RBF spatial prediction method in abased GIS model can be utilized for developing the zoning maps. Hence, it can be used as a tool for distribution air pollution over a megacity. In this paper, the results show that the highest PM\textsubscript{2.5} concentrations have been occurred in the winter especially at the center, south, and in some cases at northeast of the Tehran, during the period from 21 March 2013 to 20 March 2014. By performing analysis on the errors, the numbers of neighbors were estimated. In this method, the numbers of neighbors in the model for each function were varied from 3 to 15. The results indicate that the models with 4 neighbors have the best performance with the lowest RMSE values. Health risks assessment and its zonation with application of AQI calculator indicate that, the most and less favorable health conditions happen
during spring and winter respectively. However, the most critical zone is city center that is symbolized with red color.

6. REFERENCES


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