

## The Application of GIS in Site Selection and Space-Place Analysis of Pollution and Air Pollutant Sources in Metropolitan Kermanshah

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### Introduction

The process of urbanism in countries that are developing, like Islamic Republic of Iran with increasing in the number and the size of cities and the fast population admission have caused problems including in-official economics and in-official settlement led to high population concentration in main and old places of city and increase in air pollution in cities (Pazhouhian and MoradHasel, 1386). The most atmospheric pollution of the big cities of Iran has direct relation with the kind and the rate of the pollutants in crowded places and full of population.

In this study, we have used density classification method for studying relation between population and quantity and kind of atmospheric pollution in the big city of Kermanshah based on estimating number of people and calculating pollution in statistical blocks including 62 statistical point samples with determining rate of quantity of populations and geographic position of the study area by using Global Positioning System (GPS). Statistical populations of this research are including quantity of populations and quantity and kind of pollution in 7 days time period in the suburb of Kermanshah City.

Using Geographical Information System (GIS) has high advantage as a main tool for geographic analysis to recognize existing law in relation between human and environment. Using GIS in study and analysis of space-place distribution of pollutant area with quantity and kind of air pollutions was started in 1970. This will be possible to provide the place station data, order and spatial pollution data, assimilation data and spatial analysis by the facilities and technique of this system. Preparing place data station about parameters including kind of pollutants, determining geographical coordinate workshop, factories and busy population place, quantity of air pollution and usable managing possibility for interring, saving, updating and taking data with speed and high quality are main ability of geographical information system technology (GIS central of Tehran municipality, 1384).

Geographical information system with the decision support system (MCDM) can be used effectively in scanning and managing of atmospheric pollutions data for studying place distribution of differential pollutants and evaluations trend rate of pollutant quantity as an environmental decision support system (EDSS). The EDSS is useful in controlling and intelligent managing of critical pollution in the big cities specially Kermanshah.

Cheraghi in a research entitled "studying comparing of air quality in Tehran and Isfahan cites offer ways to improve" topic of working in 1387. He concluded that the most pollution is recorded in June, September, October, and January for Tehran and also in June for Isfahan. Furthermore, this study shows that 60 percent of the days have been above standard index. Ardakani & Cheraghi in research with "sanitary quality evaluation about the air of Tehran with air quality index to measure station of air pollution separately" showed that air quality of Tehran city has been increased above standard limit according to EPA for 261 days in 1385. Mousavi, in a study entitled A Comparative study of air quality in Tehran since 1997 to 1998 concluded in 1997 that air quality in 32 percent of the days have been insanitary and 5 percent of the days have been very insanitary.

### Discussion

United States Environmental Protection Agency EPA selected 6 main pollutions as criteria and divided to 2 primary and secondary categories. Primary pollutions are substances that inter directly from sources into the ambient air including five pollutants that are carbon monoxide (CO), nitrogen dioxide (NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), particulate matter with diameter less than 10 microns (PM-10) and lead (pb). Secondary pollutants refer to material that produced by interactions in the air surrounding ground and in this category is ozone (O<sub>3</sub>).

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### The air pollution index

One of the most widely used index for reporting and comparing the air pollutant is PSI index (Pollutant Standard Index) that has been developed by the Environmental Protection Agency of America (ESI). The index is calculated based on measuring concentrations of five major air pollutants (CO, PM<sub>10</sub>, O<sub>3</sub>, SO<sub>2</sub>, NO<sub>2</sub>) and it is possible to convert PSI index.

### Data used

Materials and tools have been used in the research include:

1. Maps of (a population density map with scale 1: 25000, highways and streets maps, prevailing wind direction maps, preparing DEM), to determine geographical position of the urban place of study area (statistical samples) by GIS
2. The software used includes: Microsoft Office Excel, Arcview, GIS and lateral Software as Crime Analysis and Case
3. Statistical data and population data

Process of this study involves the following steps:

First stage: library review for previous researches, characteristics of pollutants, and the evaluating of layers for GIS.

Second stage: collecting and entering data, positions, elevation points, extra separately in Excel software (Excel) with dbf format that have been stored in separated columns.

Third stage: calling data and statistical tables on the Case and Crime Analysis software

Fourth stage: determining positioning points of air pollution measuring stations, recognizing major pollutant point of city, direction and kind of pollutants distribution are in the city surface based on the kind of pollutant scene of height and density of pollutant, determining air pollutant index as kind and quality of air in emergencies and crises time to (digital layers) format in the Arc GIS software.

Step five: preparing of digital maps and graded class of the effected parameters in the production and distribution of pollutants.

### Materials and methods

The research is based on density classification method on bill of population amount and pollutants measuring on the statistical blocks that included 62 statistical point samples with geographical places by GPS for studying the relation between population to amount and kind of pollutants in the big city of Kermanshah. Statistical population in this research is population data, pollution quality, and kind of pollution that are collected for a period of 7 days in Kermanshah. The basic tests that used are median center tests, distance from standard deviation and ellipse of standard deviation. Near neighbor index has been used for identifying the quantity of air pollution between clustering tests. GIS and GPS and pollutant measuring tools and Case & Crime Analysis software it is possible to recognize the place of pollutants in the city.

### Statistical methods of basic graphic

The first group of place analysis method is basic graphic statistical methods that by quality attention to center and space distribution of pollutants recognize the geographical suburb of the city. Standard deviation Ellipse and median center points are comprehensive statistical tests. Median center point can be used as an approximate index for comparing of space distribution of pollutants place or study about kind of specific pollutants in the time periods.

In other word, the median center has been determined in central location to basic average of all forms of contaminated sites. Standard deviation Ellipse has been showed in dispersion levels of the places of air pollution.

### Median center and standard deviation ellipses

The median center of the polluted sites (air pollution) is based on five major air pollutants (CO, PM<sub>10</sub>, O<sub>3</sub>, SO<sub>2</sub>, NO<sub>2</sub>) of Kermanshah city that are located on Azadi Square, across the Shahid Beheshti Boulevard from the 22 Bahman Crossroad to Sepah Square, Modares Crossroad to Aiatollah Kashani Square, Shahid Ashke Talkh Street to end of Jalili Street, the suburb of Azadegan Square. Ellipse standard deviation shows pollutants distributional area of Kermanshah that has a stretch from north to south.

### Kernel density estimates test

Kernel density estimate test is one of suitable methods for drawing statistical data and analytical-definitions as the smooth surface in the geographic areas. Kernel density estimates test make smooth surface of data density changes as amount and kind of pollutants in the site. This calculation was done by Arc GIS software based on mentioned methods.

Analytical method for Kernel test is another way for space analysis of air pollutant in cities. In this method, relation between quantity and kinds of pollutants to density of population is measured in geographic units with specified dimensions.

### Conclusions

Results show that the emission of 5 atmospheric pollutants follow clustered patterns in Kermanshah. Geographical distribution average center of air pollutant point are coordinate toward city center (Nawab three ways to Kashani Square). Ellipse standard deviation of the pollution has been stretched in the North West, and South East. Closer look at the standard ellipse of distribution is showing more stretch directed toward South East. The nearest neighbor index of statistical test has been used to determine the random distribution or clustering of Atmospheric pollutants emission in prepared research. Quantity of the nearest neighbor index in the distribution of pollutant points is equal.

**Table 1. The amount and kind of atmospheric pollution in the city of Kermanshah**

O <sub>3</sub> (ppm)	CO <sub>2</sub> (ppm)	NO <sub>2</sub> (ppm)	NOX (ppm)	SO <sub>2</sub> (ppm)	PM <sub>10</sub> (µg/m <sup>3</sup> )	Kind of air pollutant
73.91	7.79	138	136	56.58	89.85	Quantity of air pollutant

Source: the authors

The distribution quantity of atmospheric pollution with 5 pollutants (CO, PM<sub>10</sub>, O<sub>3</sub>, SO<sub>2</sub>, NO<sub>2</sub>), from insufficient fuels of petrochemical industries have clusterly distribution with the statistical form. Because when the result of the nearest neighbor index test was smaller than that showed measured information has cluster pattern in polluted place of city.

In addition, Kernel density method that's more suitable for drawing geographical statistical data, particularly on time and location, was used to determine and analyze characterizes of 5 pollutants (CO, PM<sub>10</sub>, O<sub>3</sub>, SO<sub>2</sub>, NO<sub>2</sub>) as the amount and direction of distribution in the Kermanshah. It was determined based on this method that major concentrated atmospheric pollutants are resulted from fossil fuel of cars in Azadi Square, across the Shahid Beheshti Boulevard from the 22 Bahman Crossroad to Sepah Square, Modarres Crossroad to Aiatollah Kashani Square, Shahid Ashke Talkh Street to end of Jalili Street, Suburb of Azadegan Square. Main centers of 2 inferior places are located in Moalem and Elahieh, small towns in Kermanshah.

**Keywords:** environmental pollution, Geographic Information Systems (GIS), Kermanshah, space-place Analysis.