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Evaluation of the condition of air pollutants in Mashhad city at different stations by using the Inverse Distance Weighting method

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Abstract: Mashhad City (located in North-East of Iran) is the second metropolitan city in Iran after capital which is Tehran. Every year, a considerable number of domestic and foreign pilgrims and tourists visit Mashhad and therefore taking air pollution in this city into account would be an inevitable urge. Environmental science engineers have found some solutions by looking at the map of dispersion of pollutants and combining them through Geographic Information System (GIS). In this research Mashhad City's air pollution data and geographic coordinates of 11 urban air quality monitoring stations have been gathered by referring to Environmental Pollution Monitoring Centre. Data gathered from those 11 stations in the year 2015, including Particulate Matter (PM 2.5), Ozone (O3), Sulfur Dioxide (SO2), Nitrogen Dioxide (NO2) and Carbon Dioxide (Co2) were put into Excel (software) and five tables of Mashhad City's main pollutants (Carbon Monoxide, Ozone, Nitrogen Dioxide, Sulfur Dioxide and Particulate Matter 2.5 micro meter) were designed. Then using ARC GIS 9.3 (software), Geographic Information System analysis of dispersion of pollutants in the city was conducted. Finally, the analysis of the condition of air pollutants in Mashhad City was studied. In this study, using existing information on air pollution in Mashhad city and referring to the Environmental Pollution Monitoring Center and using the GIS, we analyzed the air pollution situation in the city and it was observed that in January, it has the highest levels of contamination. The pollutant responsible for this month is suspended particles.

Keywords: Mashhad, Pollutants, Inverse Weighting Distance, GIS

1. Introduction

Air and health quality of air as an inseparable part of human life in the last few decades has been one of the most controversial environmental issues (Block et al 2012). Air quality of cities has always been vulnerable to different degrees of pollution, due to the mass accumulation of factories and industries in the suburbs as well as the presence of private cars in the city center (Nicolas et al, 2008). There is an intimate connection between the health of people in communities and the quality of the air where they live as so many different reports have shown the relationship between air pollution and many somatic and psychosomatic diseases, including cardiovascular disorders, pulmonary inflammation, bronchitis and

many others (Grigg, 2012, Qiu et al,). Today, population growth and urbanization have put human-environmental relationship at risk. Some major problems in cities, metropolises in particular, are environmental instabilities and air pollution. Now, the fast-paced growth of the cities in Iran, especially metropolitan areas, has resulted in many environmental problems and has brought them to instabilities.

2) Problem Statement

The health of people in the community is directly influenced by the air quality of the area they live. Transportation of vehicles, industrial activities and increased use of fossil fuels are the main sources of urban air pollution. The impact of air pollution on human health and the environment have increased by which respiratory system disorders like asthma and bronchitis are notable (Ruud Germy, 2004). Primary elements of air pollution include carbon monoxide, sulfur dioxide, nitrogen oxides, particulate matter and hydrocarbons (Imani, 2014). Expeditious process of development has caused various environmental crises and endangered the lives of all creatures on the face of the Earth (Omrani et al., 2007). Recently, human being has realized that the loss of the environment is synonymous with the extinction of human life on the planet (Malakotian & Yaghmaeian, 2004). Abundance of urbanization and industrial activities in large cities has led to enormous changes in the physical characteristics of the outer layer of the earth and greenhouse gas emissions-which results in air pollution, temperature changes and other parameters-end in thermal islands (Ranjbar Sadat Abd, 2005). A proper urban environment is one of the factors which influences the quality of life among humans and the use of legal instruments will make it even more becoming (Ghorbanifar & Firoz Zare, 2009). A matter of global concern which is one of the pillars of the life is environmental conservation. Currently, the environment is exploited freely and unlimitedly due to the lack of special laws and regulations and a lack of specific ownership rules, which results in the destruction and creation of various pollution in these areas. As a matter of fact, not only effects air pollution the health but also economy and the environment. In Iran, air pollution in many cities including Tehran, Mashhad, Tabriz, Shiraz, Karaj, Arak, and Ahvaz has reached a dangerous level. Transportation and industry sectors are, respectively, the most important pollutants of the air in Iran. Following the whole country, Mashhad City is not an exception and transportation is the main cause of air pollution. Therefore, taking some measurements towards reducing the pollution caused by these two sections, will undoubtedly considered as an important step towards a healthy environment, clean air and a sustainable economic growth in the city. Having said that, solving pollution problem will save additional costs like cleaning costs and long term planning expenses through preventing waste production, reducing waste disposal costs and preventing lack of productivity (Sadeghi & Torky, 2007). Hence, in the first step, knowing the level and condition of air pollution seems crucial if the next steps need to be taken.

3) Materials and methods:

Nowadays, there are several ways to measure air pollution one of which is integration of information on air quality monitoring stations and spatial analysis. One of the methods of spatial analysis is Inverse Distance weight (IDW) (Basu et al., 2004). In this approach, it is not necessary to determine the pattern of spatial variations. The reverse of the distance is an average weighting method in which the data are weighted and weighted through the standard deviation of one point of the other points using the nodes (Zareian et al, 2009).

3.1) IDW:

Inverse distance weighted (IDW) interpolation determines cell values using a linearly weighted combination of a set of sample points. The weight is a function of inverse distance. The surface being interpolated should be that of a locational dependent variable. IDW neighborhood for selected points can be changed to vary the result. When you are given known values, interpolation estimates unknown values. To estimate the point in between, draw a dotted line to the x-axis and then to the y-axis. It's just a linear interpolation. Interpolation in GIS works the same. You need to take known points and create a surface by estimating unknown ones (Tagizadeh & colleagues, 2009).

3.2) (IDW) method

First weights are assigned to each point, then points together as triangles and defines a broken surface and passes through the sampled points.

(1). W= (I/di) nWi Zi/ Wi

3.3) Exponent:

Increasing and decreasing the dependence of cells that are unknown to the cells is determined based on the reciprocal exponent of the distance

(2). N3>N2>N1

The higher the exponent of N can be, the greater the distance effect in interpolation. Now, for calculating N, the minimum RMSEPE value (Root Mean Squared Predication Error) can be used.

RMSPE= Σ ($Zi - Zi$) / Number of control points

The lowest RMSPE is the best exponent for the (IDW) modeling, with increasing N, the distance impact increases and closer points gain more weight. The exponent is closely related to the role of the distance in the estimation of the unknown points, or in other words, it increases the exponent of the distance effect in the interpolation. This means that the similarity of the unknown points to the nearest neighbors becomes greater by increasing the exponent in the model. When the power is zero, the role of the distance is the same. An unknown value is obtained from the mean of neighboring points, and if the exponent increases, the distance effect increases, and closer distances get higher weights. (IDW) modeling is usually used with exponents above one, namely two. That's why they are called the opposite square root.

3.4) Neighborhood in (IDW):

Neighborhood in this model is defined in two ways:

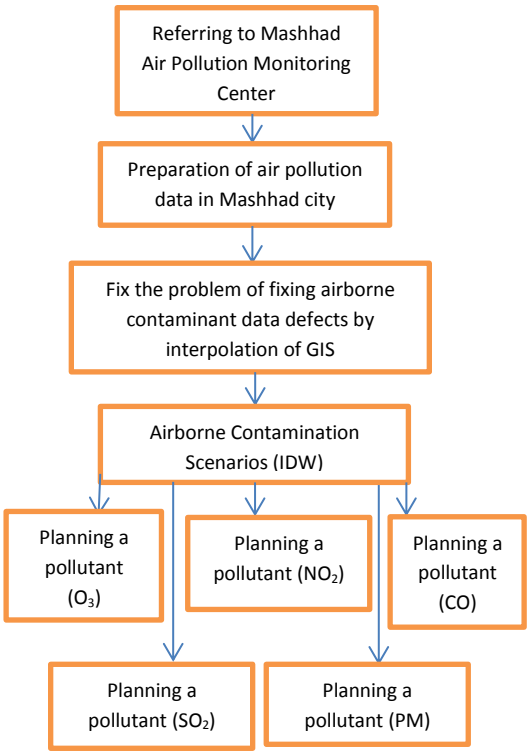
3.5) Radius search approach:

In this method, a circle is considered and an unknown point is located in the center. The point at the center of the circle has an unknown value. To calculate its amount, the points inside the circle are used. In other words, the distance between each of the point's five points inside the circle is measured. Then the reversal of those distances is calculated as the exponent, and its average is considered for the unknown point. The exponent value is actually the weight given to the distances. Determining the size of the search radius depends on the distance between the points and the way the phenomenon changes continuously.

3.6) Neighborhood Quantity approach:

If the mode of phenomenon's change is irregular, then the number of neighbors is used. The calculation in this method is similar to the Radius search method, with the difference that the number of neighbors is the criterion for selecting points for interpolation.

3.7) Steps to investigate:



4.) Analysis of the air pollution map of Mashhad city

4.1) Map analysis of Nitrogen Dioxide zoning:

In general, cold seasons have a higher average than warm seasons. This is due to inversion and accumulation of pollutants in the city. The highest amount of nitrogen dioxide contamination was recorded in Sajjad, Sadaf, Nakhrisi, and Villa stations. In terms of annual standard, only Machineabzar station located in the suburbs and Khayyam, Lashgar and Torog were in good condition. According to the map, the maximum amount of this pollutant is 40/69 and the lowest amount of this pollutant is17/16. Given the standard deviation of 756/16 and the mean of 21/24, the widespread variations in mean relative to the standard deviation indicate the distribution of this pollutant in the city.

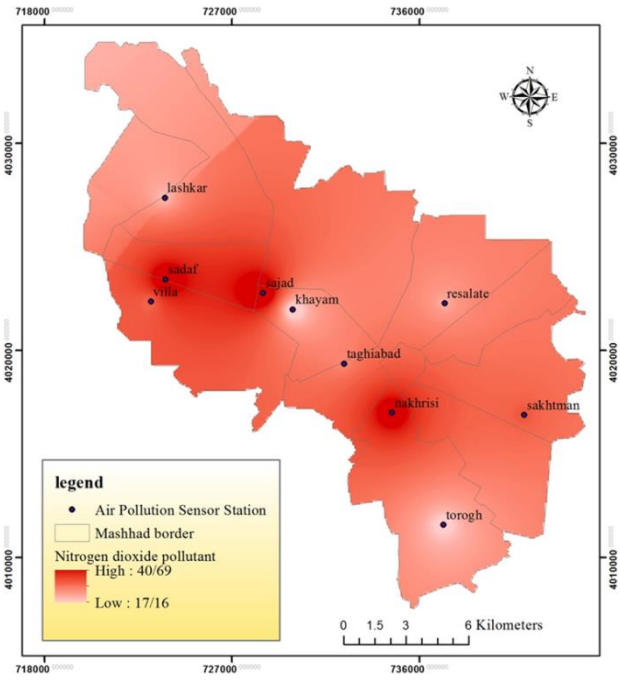


Figure (1): Nitrogen Dioxide pollution map

4.2) Map analysis of Carbon monoxide zoning:

The average concentration of this pollutant in the middle of the year is lower than the early and the end months of the year and had the highest amount in February. The lowest concentration was in the month of August. The highest annual average was observed in Sadaf, Sajjad, and Khayyam stations which is the main reason for traffic congestion in these stations, and the lowest amount of carbon monoxide was recorded in Torog and Resalat stations. According to the map, the maximum amount of this pollutant is 73/38and the lowest is 21/10. The standard deviation is 65/359 and the mean of 47/24 represents a large change in mean versus standard deviation.

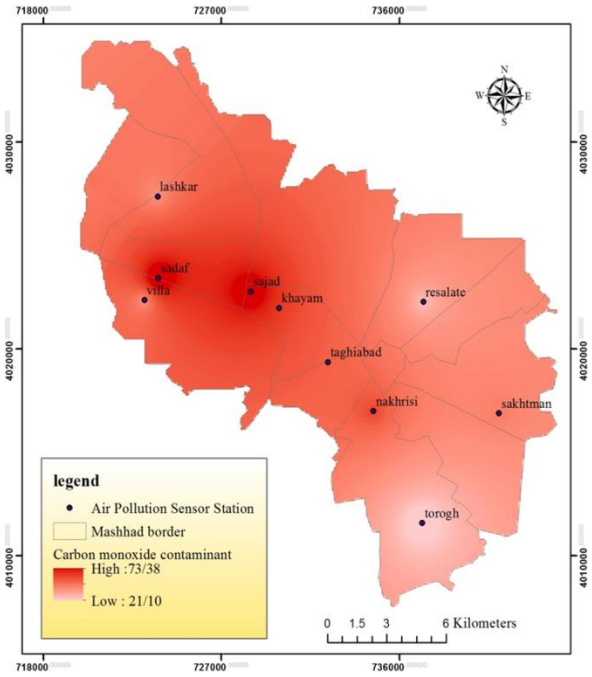


Figure (2): Carbon monoxide pollution map

4.3) Map analysis of ozone zoning:

The highest ozone consistency occurred in September and the lowest was observed in December. Ozone is a secondary pollutant and depends on the amount of sunlight, therefore, the rate in the first half of the year- which has more sunny hours-shows a higher number. On the other hand, Machineabzar station located in Toos industrial town and Villa station has the highest amount of pollution. According to the map, the maximum amount of this pollutant is 39/58 and the lowest is21/18. The standard deviation of 629/84 and the mean of 30/38 indicates the extent and dispersion of this contaminant, especially in the western, southern and parts of the central areas of the city.

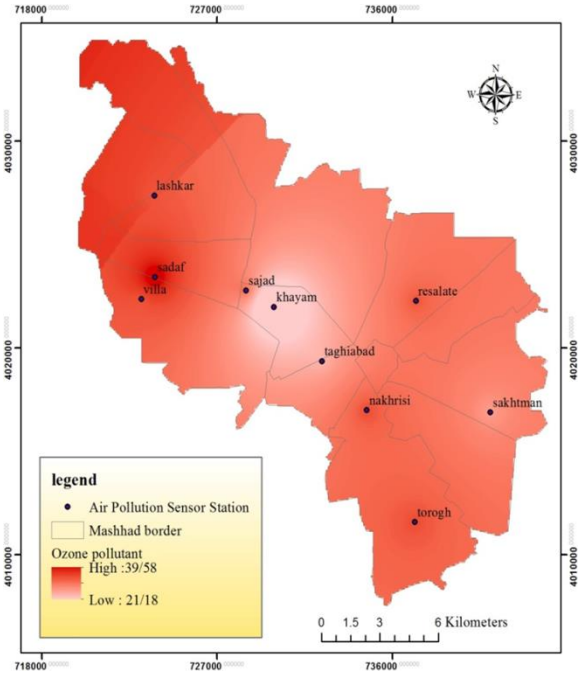


Figure (3): Ozone pollution map

4.4) Map analysis of Particulate Matter zoning:

The highest density is related to Resalat station. This can be attributed to the traffic load and the presence of metropolitan projects. The results of this study showed that the city of Mashhad is in a very poor state due in terms of Particulate Matter contamination. On top of that, the highest density of this pollutant occurred in March and its lowest level occurred in July. In other words, the second half of the year has a higher concentration. The role of some particles like dust in fluctuation of particulate matter and reduction of rain is well visible. According to the map, the maximum amount of this pollutant is 30/38and the lowest amount of this pollutant is 15/12. The city of Mashhad is in desperate condition for this pollutant. The standard deviation is 1/6 and the average is 22/75, and it can be concluded that the highest amount of this echo can be found in the eastern part of the city due to the city being located within the metropolitan area. The smallest amount of this pollutant is related to the southern regions and Central and parts of the western part of the city.

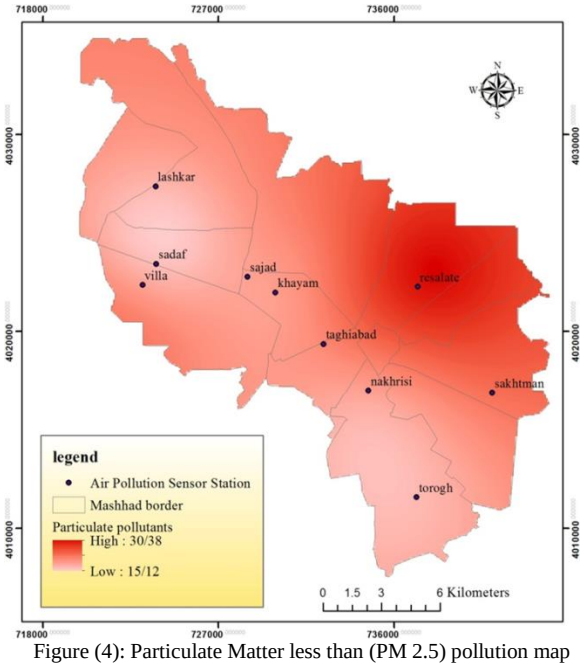


Figure (4): Particulate Matter less than (PM 2.5) pollution map

4.5) Map analysis of Sulfure dioxide dioxide zoning:

The maximum consistency is related to the month of December and the lowest is in September, and generally, during the cold season, it has a higher average than the warm season. This can be due to inversion and accumulation of pollutants in the city, thus, it is rated as an unhealthy condition in the view of annual standard. Lashgar and Taghi Abad stations showed a higher average compared to other stations. Resalat and Villa stations had the lowest rates compared to other stations. According to the above map, the maximum amount of this pollutant is 16.33 and the lowest amount is 11.77. The deviation is 50/83/83 and the mean value is14.05. Extensive changes in the mean relative to the standard deviation indicate the dispersion and spread of this pollutant in the city.

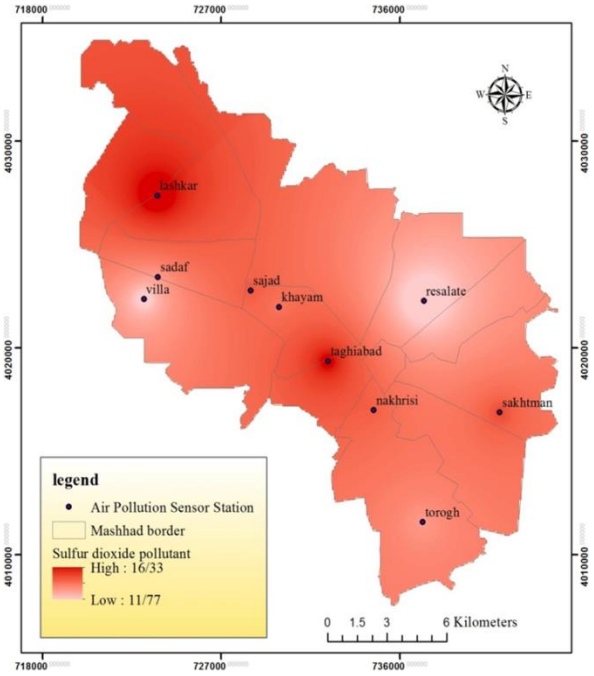


Figure (5): Sulfur dioxide pollution map

5) Discussion and Conclusion

Proper management of urban systems requires a perfect understanding of the nature of the components of different regions, how their properties are influenced by regional events, and how the components interact to changes or create a new effect (Jurgen etal, 2008). Inappropriate distribution of urban utilities that are one of the most controversial issues in cities, large cities in particular, can create environmental instabilities such as air pollution in cities. According to the maps, it can be concluded that in the second month of the year, there is the highest rate of contamination. The pollutant responsible for this month is particulate matter. Among all stations, Sakhteman station had the highest amount of this pollutant, which can be attributed to the larger population and consequently to the increased traffic of worn out vehicles and to the greater amount of industries in this part of the city. also had the smallest amount of this pollutant at Resalat station, which can be due to the low population density and, consequently, less traffic in that area. Nitrogen dioxide in Khayyam and Sadaf stations in the three months and also in Villa, Nakhrisi and Torog stations in January, was higher than the average standard. The highest average annual consistency of carbon monoxide was observed in Sadaf, Sajjad, and Khayyam stations, which the main reason is traffic congestion in these stations, and the lowest amount was recorded in Torog and Resalat stations. On the other hand, the highest concentration of this pollutant occurred in March and its lowest level in July. In other words, the second half of the year had a higher level of pollution. Micro-particles have a palpable impact on fluctuation of particulate matter. Sulfur dioxide at Lashgar and Taghi Abad stations show a higher average compared to other stations. Also Resalat and Villa stations had the lowest rates among the other stations. The highest density of ozone was recorded at Machineabzar station located in Toos industrial town and Villa station had the highest polluting rates. The highest amount of nitrogen dioxide was at Sajjad, Sadaf, Nakhrisi, and villa stations. In terms of annual standard, only Machineabzar station located in the suburbs and also Khayyam, Lashgar and Torog are in an acceptable condition.

6) Research constraints:

A) Strict organizations in providing statistics.

B) False and limited data.

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