Air Pollution Zoning based on Land use and Traffic of Vehicles

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Abstract: - Worldwide statistics indicated that around 4.5 million people die every year due to air pollution. This issue caused by traffic and industrial factories. It is obvious that to reduce air pollution, a comprehensive plan is needed. One of the most important steps to achieve good results is trip demand management which is dealt in this study.

For this purpose, the city of Mashhad, the second major city in Iran, is selected, as a case study. By using Geographic Information System (GIS) and TransCAD software, the OD matrix is assigned by user equilibrium method. Finally, to develop trip demand management strategies, areas with more pollution productivity, based on land use and amount of vehicle traffic is determined.

As the result of this research implies, traffic control zone for heavy vehicles and personal vehicles at critical times can be identified or land use policies can be revised.

Key-Words: Air Pollution- Geographic Information System – Urban Planning- Environment

1. Introduction

Five substances are known as air pollutants which cause more than 90% of environmental troubles. These factors are CO, NOX, HC, SOX and suspended particles. Suspended particles are the most dangerous air pollutants. Despite of small share of diesel vehicles in traffic jam but diesel vehicles cause more suspended particles and nearly all SOX emissions.

According to the estimation made by air pollution control plan due to transportation system, trucks and buses share, in the emission of pollutants, is about 70%. If the current trend continues, this share will increase from 70% to 76%. While, in our country, the rate of sulfur and pollutant elements, in gasoline, are at least 100 times more than the standard universal gasoline, as it is in Euro 3. [1]

For instance, toxic gases and smokes along with various pollutants in Athens which caused destruction of ancient buildings, made Greek government to take necessary actions in order to decrease acid raining up to 40%, during the past twenty years. Those actions included traffic restrictions in central areas of the city, even and odd plate restriction during critical times. [1]
Besides these policies which are used in Greece, many other preventive programs are also used in most large cities to reduce air pollution.

Constraints in Tehran such as congestion pricing or even and odd plate restriction plan cause reducing of pollutants emission, especially in the congestion pricing area up to 12%.

But air and noise pollution level in Iranian large cities especially in Tehran is more than world standards. Permissible noise level in residential areas is 80 dB but most Iranian large cities such as: Tehran and Mashhad are faced higher noise pollution than universal standards.

A few years ago, a ten-year plan was started to reduce air pollution. But the only serious steps which are taken are: making people aware of the air pollution state and suspension of schools and governmental offices.

As it is noticed, to achieve acceptable results in relation to the city air quality, a comprehensive program is required. Focusing on only one program or some programs may worsen the situation. But one of the most important measures in reducing air pollution is traffic demand management, which is the objective of this research.

2. Objective Research

According to the law which was passed by 15 members of EU, all cities with over 250 thousand people and roads with traffic levels more than 6 million vehicles per year must have air pollution maps. In this regard, the city of Mashhad was selected as a case study which despite of having the above specifications, a holy shrine is located in its downtown which gives a special aspect to this city. In this study, by using trip distribution pattern between 253 TAZ¹ and different types of land use and residential population density, air pollution zoning have been determined.

3. Case Study

Mashhad with area of around 275 square kilometers and population of 2500000 is considered as the second largest city in Iran. This city is an industrial city with enormous industrial and manufacturing units. In addition, it needs more preventive attention on air pollution because of the pilgrimage structure and space around it. But until now, no preventive program or plan is considered, in this respect. So this research can be considered as the primary effort to aid the future studies.

Integrating and classification of different data layers make ready to analyze different aspects of air pollution and the impact of traffic and especially large vehicles on air pollution. So in this study, GIS software is used for analysis and zoning.

Descriptive and data layers include:

1- Non-residential land use layer
2- Parks and green urban spaces
3- Network layer
4- Residential population density in study area
5- Trip distribution matrix between 253 zones
6- Zone layer and land use areas

3.1 pollution zoning based on land use

Based on environmental Research Center law, residential zoning include zones that the most land use is residential and the main function of it is residing activities. In these areas, providing comfort and security of residents is the base of land selection and land use is only allowed to settle people.

Also commercial zone include commercial-service land use and residence is prohibited or restricted over there.

Industrial zone is defined a zone which contains the industrial land use and is based on environmental consideration in terms of distance from residential areas which is located outside the city. Factories, industrial production and service workshops are located in these areas.

As it is displayed, pollution caused by industries and traffic of vehicles, can be seen in Figure 1. Non-residential land uses in all traffic zones, in Mashhad, has been separated from industrial, commercial, green space, military and transportation zones.

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¹ Traffic Analysis Zones
Based on the average pollution produced by each of the different land use, each zone has been shown based on the rating of high, medium, low and very low. The combined weight based on the effective area land use pollution is produced. Industrial zones as the most critical areas, in terms of pollution, are considered with high grade, residential with low and green spaces with very low grade. The area of infection, the geometric center of zones with higher air pollution and the effects of specified pollution produced in one km radius of these areas, are shown in figures 2 and 3.

Fig.2- Critical zone in terms of pollution

Fig.3- Population density in TAZ

Among these, Zones with more pollution and high population density has been selected as critical areas in air pollution. Figure 5 shows this zones and population density around them.

Fig.4- population density in TAZ

Fig.5- Zones with more population density and more emission

3.1 pollution zoning based on vehicle traffic

As it is mentioned in introduction, many particles of air pollutants are due to fuel of vehicles which travel daily in the city. Therefore, in addition to analyzing the land use, daily traffic volume of vehicles should be studied.

For this purpose, trip distribution matrix of the passengers car, equivalent resulted from Mashhad comprehensive study in 2010, is used. This matrix shows the distribution of all daily trips between 253 zones which is the result of OD surveying. [5]

Different assignment models can be used such as All or Nothing technique (AON), Logit models, User Equilibrium (UE) or stochastic methods and some other models.

In this study, User Equilibrium model is used. Because these classes of models obtain suitable vision of reality of urban networks and their density.[3]

User Equilibrium algorithm acts are based on minimizing the cost of users in each iteration process.
In this study, BPR function\(^2\) is used as cost which considers the effects of capacity, density, type of roads and travel time. This cost function considers travel time as a function of vehicle traffic and is the most function in transport studies. Constant parameters, capacity and free flow travel time values for different type of road is derived from surveying in the comprehensive transport study for this city in 1999.[2]

![Fig. 6: Mashhad urban network which is separated on different type of road](image)

Thus, by using TransCAD software and UE approach, volume of vehicles are assigned to networks and figure 7 shows the average of daily traffic.

![Fig. 7: Average daily traffic are assigned to network](image)

Based on studies in Environment Research Center, traffic pollution is effective to intervals listed in table 1. [1]

![Table 1: minimum distance influence from streets based on average daily traffic](image)

According to the standards, stated in table 1, depending on assigned traffic, air pollution zoning has been determined around each arcs of network. With integrating results from traffic pollution analysis and emission zones from industrial land uses, contamination zoning is achieved and is displayed in figure 8.

![Fig. 8: Integrated pollution produced from traffic and industrial land uses](image)

As the above figure shows, central business districts (CBD) especially around the holy shrine have highest air pollution and highest traffic of vehicles which this result can be considered in determining traffic management strategies. Thus the results of this paper can be used in determining congestion pricing limitation or enforcement on restricted areas for large vehicles during critical times.

4 Conclusion

In this research, which is based on network characteristics, trip distribution matrix is assigned by using UE method. Then based on existing standards, air pollution zoning is determined. Thus, based on obtained zoning maps, it can be proposed for congestion pricing zones or restricted areas for heavy vehicles.
In addition, in long-term urban planning and land use change strategies, serious efforts should be made. These efforts can include: changing location of heavy vehicle terminals, industrial land uses, patterns of land use licensing or development of urban green spaces, substitution of natural-gas using cars and population control strategies.

Short-term travel demand strategies are the other results of this study which include determining permitted routes for heavy vehicles or temporary restriction on entering of vehicles in critical circumstances. These results can guide us in future studies.

It is also worth-while that urban authorities and managers by allocating necessary facilities and investments in collection, preparation and management of data, provide rapid and timely access to these information. These data should be gathered in environmental management modules in ITS architecture in future efforts.

References:

2. *Mashhad Comprehensive Studies*, Transportation Research Center of Sharif University (MOMTAHEN), 2000.