A Novel and Analytical Approach to Air Pollution and the Effects of Metro in Decreasing It: A Case Study in Qazvin as Capital of the Province of Qazvin in Iran

Sadredin Alipour [a], Siavash Shamsipour Saraydashty [b,*]
[a] Department of Environment Management, Faculty of Environment and Energy, Islamic Azad University, Science and Research Branch, Tehran, Iran
[b] Department of Environment Engineering, Faculty of Environment and Energy, Islamic Azad University, Science and Research Branch, Tehran, Iran

Abstract— In recent decades, transportation problems in Qazvin are the largest crisis of the city which one of its horrible consequences is air pollution. Economic losses induced by air pollution are more than billions of Dollars. Regarding the significant contribution of vehicles in air pollution in Qazvin, developing of rail transportation system is seems to be an inevitable option as the optimum method of passenger transportation. To solve traffic problem and its consequences, rail transportation is of more effective and continuous efficiency in energy consumption than other types of transportation while its environmental impacts are less than others. In the current paper, the law of public transportation development, energy consumption management and performance of Metro Company of Qazvin were analyzed in addition to study about the resources of contamination. Further, advantages of metro was introduced and its economic consequences were quantitatively investigated and finally, the relationship between metro and air pollution was modeled with system analysis approach.

Index Terms— Air Pollution, Metro, Qazvin, Iran, Environment, Saving, Transportation

1 Introduction

Urban transportation in Iran, and especially in Qazvin, which mainly consists of private vehicles of citizens, leads to sonic and air pollutions [1-8]. As contamination is of some effects on human life of adults and minors, the authorities are thinking about the methods for resolving this problem [9, 10]. One of the most important methods is suitable development and management of public transportation and urban rail transportation, or metro, is one of the best types of public transportation [11]. Metro is the most effective type of dense urban transportation system which one of its important advantages is that its route is separate from other urban routes [12]. As a result, the traffic of metro passengers is not interfered with the urban traffic and in fact, metro support some part of traffic load to help streets of the city [13, 15, 16, and 18]. Due to the large volume of passengers which are transported by metro, it is the base of urban transportation system in mega cities and other types of transportations such as bus and taxi are used as supplementary systems of metro [13-21]. During past years, metro lines are increasingly constructed [21-23]. Today, in many cities of the world, metro is used by citizens, at least in one route, for intra-city trips [24-29].

In Iran, also, metro development is the best public service in urban transportation and is counted as a symbol of development and progress and each step toward the construction and operation of metro is an index of development [30-39]. In addition, if the construction and operation of metro is really considered as a process, it can be counted as an index of progress in development of country [40-47]. From experts' points of view, it is thoroughly accepted that effective and constitutive moving towards the development of metro can obtain a clear view for reaching to goals of perspective document [48-51]. In the current paper, the effects of metro operation on air pollution in Qazvin are studied.

The important air contaminants of cities can be categorized as the following;

Carbon Monoxide (CO): It is a colorless, odorless gas which is mainly produced due to incomplete combustion of fossil fuels. Motor vehicles are of the largest contribution in producing this contaminant [52-59].

Ozone (O_3): It is one of the most challenging contaminant which is not, basically, spread into the environment from a source. However, it is produced by reactions between atmospheric contaminants and as a result it is called the secondary contaminant. The primary contaminants which are contributed in producing Ozone are produced from vehicles and other industrial contaminants which consist of Nitrogen oxides and all hydrocarbons [60-73].

Particulate matters (PM): Any substance, except that pure water, which is presented in atmosphere as liquid or solid under

- *Dr. Sadredin Alipour, Ph.D. in Environment Management, Department of Environment Management, Faculty of Environment and Energy, Islamic Azad University, Science and Research Branch, Tehran, Iran.*
- **Siavash Shamsipour Saraydashty, Corresponding Author, M.Sc. in Environment Engineering, Department of Environment Engineering, Faculty of Environment and Energy, Islamic Azad University, Science and Research Branch, Tehran, Iran.*

normal condition in microscopic or sub-microscopic size but larger than molecular dimensions is called particulate matter. A comprehensive description of presented particulates in atmosphere can be obtained by determining the following issues: (a) concentration; (b) size; (c) chemical composition; (d) phase (liquid or solid). These particulates are divided into two categories of smaller or equal to 5.2 micron and smaller or equal to 10 micron [74-79].

Nitrogen Oxides (NOx): It is produced by generators, power plants and motor vehicles. This contaminant is the reason of bronchitis and other lung diseases [80-85].

2 Air quality index and transportation field in Qazvin

The quality of air affects quality of life and respiration of human. As weather condition has daily changes, the quality of air also can be variable. The management of monitoring and supervision of air quality in mega cities determine air quality index based on the data related to the quality of air and then, provide the required information for public. Therefore, air quality index is a key tool for recognizing the quality of air and its relationship with human health.

In general, air quality index (AQI) is an index for daily prediction of air quality. The index gives information to people about the quality of air (whether the air is clean or polluted) and presents the level of its relationship with health levels. In the other words, it shows the level of polluted air effects on human health and makes its perception easier for public.

Contamination induced by transportation is of the same important as industrial contamination due to irregular and fast urbanization. The contamination induced by transportation and vehicles is in the form of exited gases from exhaust, particulate matter, sound and etc. Today, air pollution is one of the most important and basic environmental problems of mega cities around the world which is induced by human activities and progresses. In Iran, eight mega cities are represented as contaminated cities which the first and most important city is Tehran. During recent decades, there have been various studies about the contaminant resources, production percentage of various types of contaminants, the air pollution controlling methods and environmental management methods and so on; transportation is vanguard of contaminant resources in all of those so that the performed studies were shown that more than 80 percent of air pollution in Tehran induced by mobile resources or vehicles. In an investigation, aimed to obtain statistical analyses, vehicles are categorized in specified groups. If the transportation system is divided into sub-groups as light vehicles, motorcycles, buses of United Bus Company and other diesel vehicles (including buses, minibuses, trucks and light trucks), the contribution of each group in total contamination spread in the air of Qazvin induced by transportation system.

Motorcars are of the maximum contribution, i.e., more than 77 percent of total contamination spread induced by mobile resources, which one of its principal reasons is the considerable number of motorcars in the transportation system compared to other sub-groups.

3 Legislator and intra-city rail transportation

Regarding the understanding of the public transportation condition in the country and necessity for solving the problem in the future, legislator considers improving the conditions of urban traffic along with increasing the contribution of public transportation up to 75 percent of total intra-city trips in article (30) of the forth economic development program law of the country (2004-2009); however, such condition is not obtained, practically. Also, in the development of public transportation and management of fuel consumption law in 2007, the contribution of urban train in public transportation during 2007 – 2011 is determined.

However, according to waver of the article (7) of the law, the contribution of metro, bus and taxi in Qazvin are considered as 30, 25 and 25%, respectively. The determined trend for Qazvin in the development of public transportation and management of fuel consumption law is shown along with the trend of metro development in contribution of intra-city transportation up to 2009 and its continuance is shown based on five years program of metro.

The trend of growing the metro shows that the metro of Tehran is of higher growth than the determined trend for all of the country in the enacted law, but legislator considers the maximum contribution of 30% for intra-city rail transportation in Tehran at the end of 2011. In 2007, the lines development program of Qazvin metro was reviewed to reach the determined goals in the law and according to the program, about 15000 billion Dollars per year must be expended in metro of Qazvin. However, the actual credit assigned to the metro of Qazvin has been lower than half of this number in past years. Regarding the limitations of resources and performance of metro company, reaching to the 15% contribution at the end of 2011 is possible but gaining more than it needs to coordination between upstream organizations and institutions towards the developing of Qazvin metro. According to the potential of the company, this important issue is considered in the five years program of metro company but needs to coordination of government, council, municipality and well commitment in this field.

4 Some qualitative advantages of metro

In order to guarantee the quality of life and sustainable development of cities and regions around the world, developing an integrated approach about the urban policies in economical, social and environmental fields for citizens and business is necessary.

To encounter with increasingly economical, social and environmental development of the society and in order to create an integrated public transportation system, companies and various aspects of transportation should be coordinated and move towards a specified goal with all factors. Based on the regional conditions, the most effective measures should be considered so that the considered regions along with various zones covered and political aspects also considered.

Each of public transportation policies will be successful only when it is effectively coordinated and integrated with other urban policies. This cooperation brings some advantages

for public transportation sector and other urban management fields which some of these qualitative advantages are introduced in the following.

4.1 Increasing the Transportation Speed

As metro has an exclusive route, which is frequently underground and in some regions is on the ground, it has not any interference with traffic of streets and is not encountered with limitations of traffic in urban pathways. As a result, it leads to faster intra-city trips than private cars and even than public vehicles such as bus, minibus and taxi.

4.2 Decreasing the Duration of Daily Trips

Due to central and integrated management and using exclusive route, metro can be very regular and on time. It causes the duration of intra-city daily trips decreased between 30 and 45 minutes.

According to a poll, use of metro leads to averagely about 25-30 minutes decrease in waste time of passengers. Considering 25 minutes saving in time for each trip, as an average, in all lines of metro, more than 1871 million hours is saving from the first operation of metro until the end of 2010. In addition, more than 160 million hours is saved only during 2010.

4.3 Improving the Social Relations

Increasing the population and in turn, considerable extension of urban regions and increasingly tend to use of private cars have some consequences such as anxiety and mental stresses induced by traffic. This, in turn, leads to failure of social relations between citizens. The rail transportation system of Qazvin (metro) acts as a facilitator of social relations compared to other types of individual and public transportation systems. Metro development leads to removing the obstacles, created by other transportation infrastructures such as freeways, highways and pathways which are adjacent to residential regions and make the societies isolated. Therefore, metro leads to public societies become close to each other. Further, removing the class distinctions between various levels of people is another positive effect of rail transportation.

4.4 Welfare and Peacefulness

As metro is apart from street traffic and has not any contact with sonic and air contaminants and also has a suitable air conditioning system, passengers can experience a clean and suitable environment in wagons of train. Creating mental peacefulness and hilarity for citizens cause to increasing the mental and physical readiness of people and prepare them for a better life and work and in turn, it leads to increase in productivity of work force.

4.5 Increasing the Social Regularity

The regulated urban train guidance system and exact timing of train's departure (except normal delayer factors) and also the programmed duration of train stop in each station and cleanness of interior environment of stations and trains lead to creating a special discipline so that every person of society is committed to follow this discipline. Order of the discipline can affects other personal affairs of people and ultimately, increasing the social regularity of society.

4.6 Reducing the Traffic Density

Constructing underground metro lines in city centers, especially in mega city of Qazvin, reduces the density of traffic in the streets and facilitates the traffic of private and public vehicles in proportion to its contribution in intra-city transportation. Easier and faster traffic of rescue and police vehicles also is another advantage of using metro in public transportation.

4.7 Safety and Facilitation in Intra-City Trips

One of the sensible characteristics of metro is trip facilitation by this public transportation system. In this regard, metro company is always looking for using new methods and techniques in operation and easy transportation of passengers such as;

- Mobilizing metro stations with auto selling of ticket;
- Discount for buying credit tickets with specified value;
- Providing special conditions for disabled and old persons;
- Installing of elevator and escalator in metro stations;
- Providing specified wagons at the face and back of train for women.

Trip by metro is recognized by people as safe trip. The increasing welcome of people to metro is a proof of this claim. Metro is equipped with a central and effective controlling system so that the traffic of trains is continuously under control and supervision and when any possible error is recognized, safety supervision system is operated and the train would not allow moving. In addition, metro is equipped with especial systems so that the train will not allow moving if all doors of train is not closed. However, all passengers of metro are covered with accidents insurance since arriving to until exiting from station so that if a person has any accident in the train or metro stations, all his/her costs induced by accident will be paid by accident insurance.

5 Decreasing Energy Consumption and Protecting Environment

Intra-city rail transportation has various economical advantages from energy consumption and contaminant producing points of view which some of those are briefly mentioned. In this condition, it is necessary that the contribution of intra-city rail sector from transportation market will reasonably be determined for taking these advantages so that the rail transportation system gains its suitable position in transportation industry.

The amount of gasoline saved since the first operation of metro until the end of 2009 is about 1716 million liters. Considering the world price of gasoline as 2 Dollars per liter, the value of saving is about 12012 billion Dollars. This saving is about 2121 billion Dollars only during 2009.

These savings are including saving in waste time of passengers, saving in hygienic and treatment costs induced by air pollution, saving in costs of depreciation and accessories of cars, saving in costs of accidents losses and saving in repair and maintenance costs of streets and many other cases have not mentioned in this table.

The amount of some important savings in urban costs induced by operation of metro lines in Tehran, without considering the amount of saving in gasoline and diesel consumptions, is about 4018 billion Dollars only during 2009.

6 Intra-city rail transportation system (metro)

Regarding the effective role of transportation systems in contaminants emission, one of the most important air pollution reducing methods in the cities is using public vehicles, especially metro. There are 155 million trips, daily, by metro in 110 cities of the world. Since 2000, 37 new cities including Delhi, Dubai, Sheng Yang (China) and so on are equipped with metro. The length of metro lines in China will be reached to 2300 kilometer until the end of 2015. These issues make the importance of metro more clearly for us. The construction of Tehran metro was started in 1977 and currently, it is moved towards its perspective with an increasingly speed. In perspective of 1409 and Tehran comprehensive plan, Tehran metro will be reached to 12 lines and 430 kilometer length. Quantitatively evaluation and analysis of the effect of metro on air pollution reduction is very problematic and challenging and on the other side, it is of scientific and practical importance.

7 Conclusion

Metro or underground train is a successful and redeemer method which is tested and exploited by numerous countries. Big and populated cities of the world satisfy the demand for using private vehicles in intra-city trips by means of underground and on the ground trains so that the residents of mega cities have not feel any need for using private vehicles in intra-city trips and that is the way for removing the troublesome problem of traffic in mega cities larger and more populated than Qazvin. People have not suffered from air pollution and have not sickened by numerous types of known and unknown diseases.

Metro development has the following consequences:

- Millions of passengers could be transported, daily, in a specified time and without interfering with traffic using metro.
- Qazvin deadly air pollution will be reduced so that the city will be a clean city using metro.
- People of Qazvin and other mega cities will not suffered from increasing contaminations using metro.
- Job opportunity will be provided for tens of thousands of people due to metro development (metro development in Qazvin means that at least 6 new metro lines, east to west and north to south, will be constructed in various regions of the world).
- House market of various regions of the city will be balanced when metro developed in all regions of the city.
- Illness and death toll will be considerably reduced due to metro development.
- Road accidents and their economical and life losses will be significantly reduced due to metro development.
- With developing of metro, rail industries re-enliven and while the technology in this field is progressing, productive companies of rail industries will be export their products.
- Costs and stresses of people will be reduced due to metro development.
- The hygienic, educational and urban services will be distributed among children, adolescents and adults more balanced due to metro development.
- The possibility of visiting to friends and families will be easier and the public relations will be closer and the social problems will be reduced due to metro development.

Rail transportation is not contaminative and the ratio of the amount of contaminant production in other systems to private vehicles is very low and this is the reason for low air pollution in cities that a great part of transportation is performed by public transportation systems and hence, those have not traffic problem as troublesome as Qazvin. In addition, public transportation vehicles are of payback. For example, the payback of every one dollar which is invested in public transportation is 6 dollars in US.

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