INTRODUCTION
Transport development is very essential component for the growth of any city. Transport can also have considerable environmental impacts as well. Hasty urbanization, growth of vehicular population and industries are generating terrific pressure on transportation system. Urbanization is increasing at twice the rate of total population worldwide. Population, motorization, and automobile use trends and projections worldwide during the period 1960-2010 are shown in Fig. 1. It is obvious from the figure that the urban population is increasing at a much faster rate than the total population. A recent study estimated that during the next 15 years the average annual urban population growth in the least developed countries will be 4.6%, compared to 0.6% estimated for cities in industrialized countries. As cities are major growth centre and urban populations are expanding at a very high rate in developing countries (more than 6% annually). In all over the world, more than half a million people die each year in road accidents and up to two-thirds of traffic accident injuries are suffered by pedestrians. In developing countries the injury rates of pedestrians and cyclists are even higher.

In present time, particularly in developing countries like India, 30 percent population lives in urban areas. The existing trends of urbanization inspired by better quality of life are posing manifold stresses on environment. Conjugative with rapid urbanization, each city consists of a huge number of ingredient systems. Transport is
one of them, which provides mobility, litheness and accessibility to people. Due to mixed traffic composition there is an acute appreciation of the impacts of transport on urban environment in developing countries. The environment, in which people live, can also be damaged by inappropriately designed transport systems. Rapid motorization and urbanization can bring many environmental risks and problems that can seriously jeopardize the sustainability of cities. In developing countries, the quality of air in major cities is worse than in the cities of industrialized countries. Road traffic is the major source of air pollution in most urban areas. It causes deterioration of urban air quality and its interaction with the environment causes a perceivable discomfort in daily life. In current situation vehicles contributes 60%-70% of the total emission in urban areas. Transportation sector is accountable for about 50% of the emissions of nitrogen oxide and 90% of the carbon monoxide\(^3\). These emissions damage health, especially of pedestrians and persons living or working in open area near main road. Respirable suspended particulate matter is a source of major respiratory diseases in many urban areas. Transport also causes noise and vibrations. Insensitively designed transport infrastructure is visually intrusive and by physically dividing neighborhoods and communities, can have adverse effects on local amenities, while reducing social capital. Along with over-crowding, Indian cities are crammed with automobiles like scooters and private cars, buses and inappropriate industrialization. Urban cities like Delhi is suffering from severe problems caused by transportation, such as air pollution, noise pollution, traffic congestion and open land depletion. In such type of city the risks and the problems are much greater because of speedy urbanization compared to the available resources, particularly in the emerging megacities. Due to lack of attention to the impact of transport can damage habitats and biodiversity. In such a complex situation, linkages between environmental issues, public transport, non-motorized transport and safety must be given proper and adequate attention. Since the presences of natural resources are limited, sustainable development of environmentally transportation systems in large urban cities are tremendously essential in order to maintain future quality of life.

Sustainable development meets the needs of the present, without compromising the ability of future generations to meet their own needs\(^4\). The other definition of sustainable development, which has been adopted by the International Union for the Conservation of Nature (IUCN) is the type of development which improves the quality of life within the carrying capacity of the earth's life support system\(^5\). Hence the economic and social development objective must be defined in terms of sustainability in all developed and developing countries. A sustainable transport system must offer mobility and approachability to all urban residents in a secure and eco-friendly mode of transport.

**AIMS AND OBJECTIVES**

The aim of this study is to focus the different environment related issues of the capital city of India i.e. Delhi. The paper has explained about the existing levels of air and noise pollution along bus rapid transit corridor of Delhi. The paper has also proposed ideas and challenges to maintain and create the environmentally sustainable transport systems in Indian metropolitan cities like Delhi along with debate on the current environmental troubles and poor motorized system of transport. The study is an effort to find out some technology based solution through design of noise barrier along the corridor and motivation towards the use of public transport based solution for the movement of urban transport system in the direction of environmentally sustainable transport system. The paper also
suggests some other remedial measures for a sustainable transport environment in Indian megacities.

**METHODOLOGY**

**Data collection**

For the study, bus rapid transit corridor, South Delhi has been selected to predict and observe the concentration of traffic air and noise pollution. The land use pattern of the corridor has been found primarily residential. Along with the monitoring of air and noise level, the other data like classified traffic volume, spot speed, meteorological parameters and geometric parameters have also been considered. Meteorological parameters include wind speed, wind direction, temperature, mixing height and stability class and geometric parameters consists road width, number of lanes, lane width, shoulder width, presence of medians and its width. For air pollution monitoring only two pollutants viz. carbon monoxide (CO) and sulphur dioxide (SO₂) have been preferred. For noise pollution monitoring 12 hours study has been done. Vehicle count and vehicle classification were carried out manually at the site. The noise levels were recorded in dB (A) using noise level meters. Measurements were recorded every 15 seconds for a period of 15 minutes per hour. This was considered to represent the variations in noise levels of the entire hour. The spot speeds were recorded for all categories of vehicles by using radar gun. A large number of speeds were recorded per vehicle during the entire span of the day to accurately estimate the average speeds of each vehicle category.

**Environmentally sustainable urban transport system : The need of society**

The environmental effects of transport differ considerably by mode and it also damages the global environment. Pollution from motor vehicles produces about one - fifth of the incremental carbon dioxide in the atmosphere arising from human activity (which potentially contributes to global warming) and half of the nitrogen oxides (which contribute to continental scale acidification and ecological damage). If current trends continue unabated by 2010 the developing countries could become the largest source of global anthropogenic emissions of carbon dioxide and methane⁶. Presently, the key challenge for developing countries is to identify these tradeoffs and to formulate such type of policies that can avert the environmental sustainability gap from growing wider with continued economic growth. It has already discussed about the requirement for a sustainable society in early seventies with the publication of several articles such as⁴ A blueprint for survival⁷. One of the often quoted definitions of sustainable development is development which meets present needs without compromising the ability of future generations to achieve their own needs and aspirations. According to the definition adopted by the U.N. World Commission on Environment and Development¹¹, a sustainable condition for this planet is one in which there is stability for both social and physical systems, achieved through meeting the need of the present without compromising the ability of future generations to meet their own needs. Five factors are there, which influence the transport development i.e. technology, government policy, land use planning, social and behavioral trends⁸-¹⁰. These factors influence travel behavior, mobile technology, infrastructure design, motorization and policy measures. The impression of sustainability wraps a wide range of issues¹². They recognized the different dimensions of sustainable transportation i.e. economic and financial, environmental pollution, energy consumption, wildlife deterioration and social aspects of life¹. Environmental sustainability is concerned with the promotion of livable settlements and mitigation of the unavoidable environmental and ecological impacts of transport development. The goal of sustainable transportation is to ensure that environmental, social and economic considerations are factored into decisions affecting transportation activity. During formulation of transportation-related decision, all three elements should be considered to facilitate a comprehensive impact assessment.
RESULTS AND DISCUSSION

Traffic air emission

On the basis of data collection and prediction of air pollution, the comparative study has been shown in Fig. 2 and Fig. 3. Both the figures depicted the comparative study of observed and predicted concentration of carbon monoxide and sulphur dioxide at selected bus rapid transit corridor in Delhi. The highest predicted and observed concentration of carbon monoxide is found during 10:00 to 11:00 hour whereas the minimum predicted and observed concentration is found during 14:00 to 15:00 hour. Similarly, sulphur dioxide (SO$_2$) gas is also found at the selected corridor. The maximum and minimum modeled value of SO$_2$ is found 31.57 µg/m$^3$ and 18.55 µg/m$^3$ respectively. At the same time, when it has been compared with the monitored values, a little bit higher concentration is found during peak hour. The highest and lowest concentration of SO$_2$ has been found 26.87 µg/m$^3$ and 14.43 µg/m$^3$ during 12:00 to 13:00 hour and 8:00 to 9:00 hour respectively.

![Fig. 2](image1.png)  
**Fig. 2**: Predicted and observed concentration of carbon monoxide (CO)

![Fig. 3](image2.png)  
**Fig. 3**: Predicted and observed concentration of sulphur dioxide (SO$_2$)
Vehicular noise pollution

Fig. 4 and Fig. 5 illustrates the comparative study of predicted and observed noise levels at both sides of bus rapid transit corridor. It is indicated from the Fig. 4 that maximum value of predicted and observed noise level has been found during 10:00 to 11:00 hour and 14:00 to 15:00 hour respectively, whereas the lowest predicted and observed noise level is found during 8:00 to 9:00 hour and 16:00 to 17:00 hour respectively. Similarly, Fig. 5 represents the highest modeled (65.25 dBA) and monitored (78.88 dBA) value of noise level during 10:00 to 11:00 hour and 11:00 to 12:00 hour severally. While the minimum modeled (63.72 dBA) and monitored (66.64 dBA) value is found during 15:00 to 16:00 hour and 8:00 to 9:00 hour respectively. Correspondingly from both the figures, the observed noise level is found always higher than the predicted value along both sides of the corridor during monitoring hours.

Fig. 4 : Comparison of predicted and observed noise levels at BRTS corridor (in one direction)

Fig. 5 : Comparison of predicted and observed noise levels at BRTS corridor (in another direction)
Environmentally sustainable transport systems: Alternative measures

Environmental monitoring and protection

To control the environmental pollution, there must be regular air and noise pollution monitoring at different zones like residential buildings, sensitive locations and industrial zone. There must be appropriate distance between the residential apartments and road. Those areas where noise pollution problem is existing, design of noise barrier must be there to control the excessive noise level. Construction of vibration sensitive buildings should be in a particular range of distance. New technology with fuel quality and pollution control device should be recommended in vehicles to control the traffic air emission. Proper traffic management is also a very essential part of the environmentally sustainable transport system. There must be the design and implementations of schemes that remain at a human scale and protect all aspects of human health. In order to make sure the environmental friendly transport system, it is permanently mandatory to have a concurrent assessment of environmental and safety aspects of transport system by concerning institutes, organizations and societies.

Motivation towards the use of public transport

In current scenario, public transport system can play very important role to convert the transport system into environmental friendly system. There is a need to shift from private and personal transport to public transport system to lower the vehicular emission up to a large extent. From the study it is found that the private vehicles emit about 95 percent more carbon monoxide, 92 percent more volatile organic compounds and about twice as much carbon dioxide and nitrogen oxide than public vehicles for every passenger mile traveled. Precedence should be given for the design and development of mass rapid transit system and bus rapid transit system to enhance their use in the metropolitan cities of India. Such kind of activities will be an important step towards an environmentally sustainable transport system. Along with this, it is also necessary to introduce latest engine technology fitted vehicles that ensure clean burning and combustion at the passenger loads and driving cycles in Indian megacities. Movement of buses should me in a safer speed. That can be determined by adjusting trip times and introduction of speed limiting devices in buses. Thus the public transportation will become a key aspect of the green initiative.

Preference towards NMT and pedestrian modes

To make the transport system environmental friendly it is very essential that people should be promoted towards the use of Non-Motorized Transport System (NMT). Non-motorized transport is almost entirely environmentally benign. Through the employ of this mode; it will become very easy to control the traffic emission in terms of air and noise pollution. To ensure the safety of pedestrians and bicyclist, design of urban area and road should be in a planned way. There must be a separate lane for the pedestrians and bicyclist in megacities. It is also very necessary to construct crossing facilities and under street sub-ways to secure the life of pedestrians.

CONCLUSION

Due to increases in urban populace, chaotic urban growth, motorization and industrialization, the uncontrolled problems of air pollution, noise pollution and traffic congestion in all the cities of India have been raised. In Indian megacities, the pollution levels of the pollutants have risen to alarming proportions. It is therefore, immediately required to develop a safe and eco-friendly transport environment. To achieve this objective, environmental deliberation must become an integral part of the planning of transport sector strategies as well as the design and implementation of transport projects. Before the implementation of any transport strategies, reducing life and health-threatening impacts should be the highest priority. Adequate actions must be taken in terms of cost effective technology, latest technological modifications in vehicles, designing of noise barrier, fuel quality improvement, transportation planning, properly planned management of transport system, motivation towards the use of public and non-motorized transport system etc. to provide to the need of people for an environmentally sustainable transport system.
REFERENCES


