

Vehicular Growth and Air Quality at Major Traffic Intersection Points in Kolkata City: An Efficient Intervention Strategies

Sukla Bhaduri*

*Professor, Department of Geography, University of Calcutta, Kolkata, West Bengal, INDIA. E-Mail: suklabhaduri@gmail.com

Abstract—Vehicular air pollution is a growing problem in Kolkata due to high growth of motorized vehicles. The increased travel demand has also resulted in rapid growth in the number of motor vehicles in the arterial roads of Kolkata City. The travel demand has increased likewise the number of registered vehicles is on rise and corresponds to some 52 percent growth since the last decade with less than 7 percent of effective road space leading to high automobile density, disproportionately low percentage of road network, congestion, accidents and effect on air quality. To estimate the vehicular pollution at ten major different traffic intersection points based on fume study in Kolkata, a primary survey was conducted and it has been found that the highest fume emitting vehicles dominate in Shyambazar Five Point Crossing in North Kolkata followed by Ballygunge Phanri in South and Esplanade and B.B.D Bag in Central Kolkata. According to Air Pollution Index (API) of US-EPA all the major traffic intersection points reflects high level of pollutants with few exceptions. It has been noted during primary survey that concentration of Suspended Particulate Matter and Respirable Suspended Particulate Matter are highest in comparison to other automobile pollutants in the traffic intersection points of Kolkata city.

Keywords—Air Pollution Index; Personalized Vehicles; Traffic Intersection Points; Travel Demand; Vehicular Stock.

Abbreviations—Kolkata Metropolitan Area (KMA); Kolkata Municipal Corporation (KMC); National Environmental Engineering Research Institute (NEERI); Non Motorized Transport (NMT); State Pollution Control Board (SPCB).

I. INTRODUCTION

KOLKATA is a premiere metropolitan city of India situated in the Gangetic plain of West Bengal on the eastern bank of river Hugli. Kolkata was originally a port, but at present located some 130 km away from Bay of Bengal due to alluvial deposition.

Kolkata city with a population of 4.48 million is the 7th largest city of India in 2011. However the metropolitan Kolkata hold a population around 14.1 million in 2011 making it the third most populous metropolitan area in India. [Government of India, 2013] Located on the east bank of the Hugli River, it is the principal commercial, cultural, and educational centre of East India, while the Port of Kolkata is India's oldest operating port as well as the only major riverine port. As of 2008, its economic output as measured by gross domestic product ranked third among South Asian cities, behind Mumbai and Delhi. As a growing metropolitan city in a developing country, Kolkata confronts substantial urban

pollution, traffic congestion, poverty, overpopulation, and other logistic and socioeconomic problems.

Kolkata, which is under the jurisdiction of the Kolkata Municipal Corporation (KMC), has an area of 187.33 km² with a density of population density around 24,252 /km² (62,810 /sq mi) [Government of West Bengal, 2013]. There is a decline of 1.88 per cent growth in population during the decade 2001–11, which is first ever recorded in city's history. The east–west dimension of the city is comparatively narrow, stretching from the Hugli River in the west to roughly the Eastern Metropolitan Bypass in the east—a span of 9–10 km (5.6–6.2 mi). The north–south distance is greater, and its axis is used to section the city into North, Central, and South Kolkata.

The major sources of air pollution in Kolkata city are the industries and automobiles. The other sources include construction activities, re-suspension of road dust, burning of coal in slum areas, biomass burning etc. [West Bengal Pollution Control Board, 2007]

Although 34 percent [Government of West Bengal, 2004] of total registered vehicles of the state are registered within Kolkata, a large number of vehicles registered in the districts within Kolkata Metropolitan Area (KMA) also ply on the streets of the core city areas. Most of these vehicles are petrol driven. Besides a large number of diesel driven taxis, buses, minibuses, trucks and other commercial vehicles also ply on the city streets. Growth of urban population is encountering fast escalations in urban travel demand.

A variety of transport modes, such as, walking, cycling, two-wheelers, para-transit mode, public transport, motor cars etc are used to meet these travel needs.

Travel demand is determined by a number of factors, the primary one being the size of the population.

Other determinants include: average number of journeys performed by a resident each day (per capita trips) and the average length of each such journey (trip length).

Travel demand has thus grown faster than the population because it is a function of both the rising number of trips undertaken by the incremental population as well as increased trip lengths necessitated by the expanded city size.

Further it has been found that residents on an average tend to perform more trips per day as per capita income levels go up.

The increased travel demand has resulted in rapid growth in the number of motor vehicles in the cities. Vehicle ownership in these cities has increased with rising household income, aspirations for better quality of life, enabling a market environment for vehicle purchase, increasing trip lengths and inadequate public transport system. The heavy concentration of private motor vehicles in metropolitan cities has been one of the key reasons for congestion, increased travel times, pollution and accidents.

Kolkata city has registered a high vehicular population since 1991, due to economic liberalization as well as de-licensing of auto industry.

From 1996 to 2011 the number of vehicles has a growth of about 2.00 times which numbers to 12.04 lakh in 2011 [Government of West Bengal, 2012]. The slow moving vehicles have a declining trend from 2004 to 2011. Increased dependence on personalized motor vehicles at present is becoming apparent from the rising stock of vehicular population in all the mega-cities of India and Kolkata is no exception where in 2011 total number of motor vehicles is 6.05 lakh [Government of West Bengal, 2011] which is almost 50 percent of total vehicles registered in Kolkata city. The vehicular population in Kolkata has increased at an annual growth rate of 4 percent, while the road space limited to 7 percent of the total 187.33 sq.km of Kolkata Municipal Corporation area. In terms of available surface road length Kolkata has least coverage about 1416 km, whereas the vehicular density is one of the highest nearing to 823/km though the vehicle count is also high at Kolkata [Government of West Bengal, 2013]. Over the last ten years Kolkata has experienced a huge increase in the vehicular population growth. The general rate of increase of all modes of vehicle have been nearly 7, 25,000 lakh in 1996 to 12, 0400 lakh that

is 2.8 times increase. Private cars have increased from 2.6 lakh in 2000 to 6.5 lakh in 2011 which indicates 2.5 times increase.

It is further noted that due to lack of proper and balanced public transport, the urban dwellers are shifting towards the private mode of transport, particularly the personalized motor transport. All metropolitan cities have been facing consistent rise in vehicular stock and growth in travel demand.

II. RELATED WORKS

As marked by Halder (1994) that good public transport would be a very important component of any strategy towards a sustainable urban transport system. Report [West Bengal Pollution Control Board, 2005] on Air Quality Management by Asian Development Bank (2005) focused some observation on vehicular emissions area wise with particular reference to respiratory suspended particulate matter. Bhaduri (2008) has pointed out that the personalized transport has dominated the transport profile of not only Kolkata city but all the metropolitan cities of India which is not sustainable from environment and energy point of view. Again Central Pollution Control Board (2010) has recently examined that Kolkata is holding fourth rank in terms of level of pollution after Delhi, Bangalore and Lucknow. Further, a Status Report on Air Action Plan for Ahmedabad City [Government of India, 2011] by Central Pollution Control Board (2011) has highlighted on different issues of vehicular pollution and how to reduce such menace by implementing proper traffic directives While Mahesh Kashyap (2012) [Kashyap Mahesh, 2011] has discussed the various control measures for the vehicular pollution in Bangalore city in his report entitled 'Air Pollution from Transportation Sources in Bangalore City'. Again Bhaduri (2013) has observed that all the major traffic points of Kolkata are worst affected by pollution.

III. TRANSPORT PROFILE OF KOLKATA

- The road surface area is barely seven per cent as compared to 25 per cent in the capital city of Delhi and even 20 per cent in other cities of India.
- About 20 million passengers and 11.04 million vehicles move in and around the city on almost all working days.
- There has been a rise in population of Kolkata and its adjoining areas with which the vehicular growth could not match.
- Buses operated within the city have very high emission levels, higher than two-wheelers, three-wheelers and personalized vehicles. Thus it contributes significantly to the vehicular pollution.
- In 1948 a bus system started to operate and in 1960 it already had a higher share of the market (60 per cent), those buses are most of the time violating the pollution norms.

3.1. Parameters for Traffic Movement at a Glance

There are few characteristics of traffic at major intersection points in Kolkata city:

- Traffic volume at major crossing: 1,000 vehicles per hour
- Minor crossing: 400 vehicles per hour
- Traffic flow: Only if the larger street has 1,200 vehicles flowing per hour and the smaller street at the crossing has 300 vehicles per hour.
- Pedestrian movement: At least 150 pedestrians crossing per hour
- Number of major crossings: 234
- Number of signals: 219
- Average speed in Kolkata is 19 km per hour. (Kolkata Traffic Police, 2012) [Government of West Bengal, 2012].

Table I: Traffic Profile of Kolkata City at a Glance, 2011

i	Latitude	22°23'47" N
ii	Longitude	88°23'34" E
iii	Area	187.33 Sq. km
iv	Population of Kolkata	44,86,679 (2011)
v	Population Density	24,252 person/sq km
vi	Long Arterial System	1,416.4 Km
vii	New Flyovers	6
viii	Total vehicles	12,04,000
ix	Vehicle Density (per km)	823
x	Total slow moving vehicles	26,156
xi	Road Intersections with signals	180
xii	Traffic Crossings with countdown timers	150
xiii	Traffic Crossings under CCTV Coverage	13
xiv	Air pollution cases	2,465
xv	Air horn cases	774
xvi	Percentage of pollution from transport sector	48

Source: Public Vehicles Department, 2012

3.2. Mobility and Pollution

Most of the new cars are diesel run cars, and Kolkata city is the topper in this respect. On a national scale 30 per cent of new cars are diesel driven cars. In Kolkata the figure is 65 percent. About 99 per cent of commercial vehicles in Kolkata are diesel driven. In consequence Kolkata has recorded an alarming amount of 61 percent diesel fuel combustion to ambient PM_{2.5} which is 23 per cent in Delhi and 25 per cent in Mumbai. Statistics have established the rising popularity of diesel cars. This is also evident from statistics of the increase sale of dieselization of new model of cars.

- Diesel constitutes 45 percent of total oil consumption by car users, switching over from petrol to diesel to gain economic benefits.
- In KMC area, there are about 169 fuel retail outlets. There are three categories of ownership of retail outlets.
- Company owned Company Operated: There are six BPCL, and 64 HPCL outlets

- Company Owned and Dealers Operated: There are 66 outlets of this type
- Dealers Owned and Dealers Operated: Very few of this type

IV. CAUSES OF AIR POLLUTION FROM AUTOMOBILES IN THE CITY OF KOLKATA

There are several causes which are responsible for automobile pollution in the city of Kolkata. It includes mainly:

- High emission from two and three wheelers petrol driven vehicles.
- Using of poor quality fuel which include high sulphur, benzene and olefin.
- Adulteration of fuel especially using of Katatel (Kerosene and exhaust mobile) in the engine of three wheelers that is the autos in Kolkata.
- Lacking in maintenance of vehicles.
- Large number of heavy weight old engine petrol driven vehicles in use causes high emission.
- Erratic traffic behavior leading to congestion and emit huge proportion of automobile pollutants.
- Most of the busy traffic intersecting points in Kolkata has been encroached by pavement dwellers, street hawkers and illegal car-parking, as a result widening space of the road has reduced and thereby results to huge traffic congestion in the city of Kolkata.
- Improper construction of road divider in between two lane of the road make inadequate road space which prevent better mobility of traffic and even unscientific construction of speed breaker reducing traffic speed in the city of Kolkata.
- Even improper management of traffic diversion by Kolkata traffic police and problem of traffic signaling system can create congestion which results into emission.
- Unscientific construction of flyover, size and weight of the car, inadequate traffic management emit huge amount of automobile pollutants in the city of Kolkata [Government of West Bengal, 2013].

4.1. Regular Air Quality Monitoring at Kolkata

National Environmental Engineering Research Institute (NEERI) started monitoring of air quality in early 1970's. Subsequently, in 1984 the Central Pollution Control Board and in 1992 the State Pollution Control Board (SPCB) started monitoring. Considering the changing demographic scenario at present SPCB is monitoring air quality at 19 stations throughout the year and subsequently the number stations were increased to 22 in 2001 [West Bengal Pollution Control Board, 2007] . The major stations are- Dunlop Bridge, Tollygunge, Ultadanga, Picnic Garden, Minto Park, Shaymbazar, Beliaghata, Mominpore, Baishnabghata, Topsia, Salt Lake, Rajarhat, Moulali, Behala Chowrasta, Hyde Road, Gariahat, Paribesh Bhawan and Raj Bhawan etc. The

parameters monitored are SPM, RPM, SO₂ and NO₂. The analysis of this data indicates that the pollutant of prime concern is Respirable Particulate Matter (RPM) which is roughly equivalent to PM₁₀.

V. GROWTH OF VEHICLES

Kolkata city has registered a high vehicular population since 1991, due to economic liberalization as well as de-licensing of auto industry. From 1996 to 2011 the number of vehicles has a growth of about 2.00 times [Government of West Bengal, 2012]. The slow moving vehicles have a declining trend from 2004 to 2011, (28,557 to 26,156 a decrease of about 2,401 numbers). Growth in different sectors of vehicular population would be clear from the following table:

Table 2: Vehicular Profile of Kolkata City

Growth of Motor Cars	Maximum observed in 2002-03 about 6.5 per cent. The trend still continued as more banks are willing to pay more car loans with facilities of Equal Monthly Installment
Growth of Autos	This para-transit mode is on rise though has downfall in 2008 due to scrapping of two stroke autos by the Government. However the four stroke autos are meeting the urban demand and has a big rise of 26.8 per cent in 2009-10
Growth of Buses and Mini Buses	Increasing trend has been observed over the last three years with the introduction of JNNURM buses. The maximum increasing rate in 2009-10 is 18.27 per cent whereas mini buses has a steady growth rate of 8 per cent
Growth of Two-wheelers	A major mode providing door to door accessibility and enjoying increasing popularity among the youth for speed. The increasing trend is observed since 2001.

Data Source: Kolkata Traffic Police and Tabulated by author

VI. TRAFFIC INTERSECTION POINTS

A fume study has been conducted on selected traffic intersection points in Kolkata by generating primary data during 2009 under a UGC sponsored project of interdisciplinary nature by the University of Calcutta. The following are some of the observation made on the basis of such study assisted by a Non Government Organization named as Envirocheck [Envirocheck, 2009]. West Bengal Pollution Control Board has already started monitoring the emission of fumes in their latest agenda. It is to be noted that the road-space in Kolkata is much lower than the prescribed national norm and moreover the pressure of the vehicles both of public and private category is increasing day by day. For this the average speed of the moving vehicles is getting slower, the stoppage time at the traffic intersection points are increasing which lead to greater air pollution. Moreover, many vehicles are not well maintained by the owners and not well monitored by the concerned authorities so the emission

of fumes is quite high. White fumes are generally emitted due to fuel-air mixture or excess oil burning. While, black fumes occur mainly due to coolant burn-off in the oil due to leakage. It is mostly common in older vehicles. During the study, the vehicles have been classified into four categories- two wheelers (motorcycles, scooters), three wheelers (auto rickshaws), four wheelers (cars), six wheelers (buses, trucks). For data collection from the survey stations, three time slots have been selected; i) from 9.00-10.15 am to cover the high traffic of the office-going period, ii) from 14.00-15.15 pm to cover the scenario of the afternoon period, iii) from 17.00-18.15 pm to cover the evening rush [Bhaduri Sukla, 2013].

6.1. B.B.D. Bag Crossing

Out of around 2,150 fume-emitting vehicles surveyed highest number of six wheelers have been noted, followed by four wheelers and two wheelers. The number of three wheelers is very negligible because in this area the route permit for auto rickshaws is not issued. Emission of white fumes score over that of the black fumes in all categories of vehicles. Cases of black fume emission are comparatively high for six wheelers. The pressure of the vehicles is highest during 10.00-10.15 am then it dips a bit minor fluctuations and again peaks up in the evening slot.

6.2. Ultadanga Crossing

In this station the number of four wheelers is the highest about 1,600 out of 4,800 total number of fume-emitting vehicles observed; which is about one-third. While, two and three wheelers mostly emit white fumes, four and six wheelers contribute to the white fumes too though at a lesser rate. From the diurnal vehicular flow pattern it can be seen that the number of all sorts of vehicles plying is highest during the evening 17.20 pm onwards. In general, the vehicular pressure over here is very high because Ultadanga serves as a link between the city proper and Salt lake region and through the nearby railway station suburban connection is also established.

6.3. Esplanade Masjid More Crossing

In this station about 2,300 plying fume-emitting vehicles has been recorded out of which four wheelers form the majority. The number of three wheelers is very negligible because in this area the route permit for auto rickshaws is not issued. Emission of white fume is much higher than that of the black fumes in all kind of vehicles. The vehicular flow is highest during the morning slot spanning from 9.20-10.15 am, when the office going traffic is at its peak.

6.4. Ballygunge Phanri Crossing

The total number of fume-emitting vehicles recorded at this point is around 2,500. Two, three, four and six wheelers come in ascending order if their number is taken into account. Here also the cases of black fume emission are much lower than that of white fumes. The vehicular flow is high in the morning, followed by a dip in the afternoon, while in the early part of the evening the flow increases with a sharp fall in the later half though a rising trend can be noticed after that

phase. Since, the station is located in an area which is neither fully commercial nor residential but is of a rather complex entity the vehicular flow pattern is different from other stations.

6.5. Topsia Crossing

The number of fume-emitting four wheelers is really high, about 1,100 in this station, two, six and three wheelers follow the suit, which is about 1,500 taken all these categories together. The proportion of white fume emitting vehicles is much higher. The diurnal flow of the vehicles does not show much variation, though it dips a bit during the afternoon.

6.6. Mahatma Gandhi Road and Rabindra Sarani Crossing

About 1,000 fume-emitting four wheelers have been detected. Six, three and two wheelers about 600 in number also contribute to the air pollution. The number of vehicles emitting black fumes is negligible. The vehicular flow pattern is very unusual compared to other stations. The flow peaks during the afternoon slot specially from 15.00-15.15 pm.

6.7. Shyambazar Five Point Crossing

This station is an important point of north Kolkata so the pressure of vehicles is quite high. About 3,200 fume-emitting vehicles have been detected out of which six and four wheelers form the chunk. Incidence of black fume is quite low. From the diurnal vehicular flow it is seen that the rush of the vehicles is maximum during the morning session, from 9.00-9.55 am.

6.8. Behala Tram Depot

Behala is a sprawling residential area of the city. 2,350 fume-emitting vehicles are noted. The share of three, four and six wheelers is almost equal while the two wheelers are comparatively lesser in number. Emission of white fume is much higher than that of the black one. The vehicular flow here is bit different from that of those commercial stations. The diurnal flow is stable throughout with a slight increase during the afternoon, no such office time pressure can be noticed here.

6.9. Moulali Crossing

It is one of the most busiest and congested point of the city. The commercial center’s nearness to the Sealdah station is one of the factors behind the congestion. The total score of fume-emitting vehicles is about 2,800. Four wheelers contribute to the air pollution most, followed by two and six wheelers. Black fume emission is comparatively much lower. Due to some constraints the survey of vehicular flow has been conducted for a lesser span. The vehicular pressure is much higher during the morning slot.

6.10. Tollygunge Metro Crossing

Tollygunge serves as the connecting point between the city proper and the expanding areas in the south-eastern section of the metropolis. Only in this station it is seen that among all categories of fume-emitting vehicles, three wheelers lead in the pack. The share of white fume emitted surpasses the black

fume formidably. The diurnal vehicular flow shows a descending trend as the day passes by.

All the traffic intersection points surveyed reflected high fume emitted vehicles with the exception of two, namely Tollygunge and Mahatma Gandhi and Rabindra Sarani Crossing [Bhaduri Sukla, 2013].

The following table will at a glance exhibit the profile of Air Quality in two world cities and the comparison is markedly clear as they have significantly reduced their scores at present, though Kolkata is much higher scorer in terms of pollution against that of Bangkok city.

Table 3: Air Quality Status in 2013(Kolkata and Bangkok)

Year	Pollution Index	Name of the City	Name of the Country
2012	145.50	Kolkata	India
	90.00	Bangkok	Thailand
2013	94.20	Kolkata	India
	73.73	Bangkok	Thailand
PM ug/cm3	148	Kolkata	India
	50	Bangkok	Thailand

Pollution Index is estimation of overall pollution in the city. Highest weightage is given to air pollution than to water pollution and small weightage to other pollution types.

6.11. Changes Perceived in the Physical Environments due to Air Pollution

While carrying out the study at the different traffic intersection points it was found that smog was the most common effect. While, at few stations change in the colour of the foliage was also detected, apart from several other minor effects [Envirocheck, 2009].

VII. HEALTH HAZARDS FACED

Due to the respiratory particulate matters breathing problem is the most common ailment faced by the respondents. The residents have also complained about irritation in eye and dust allergy in some cases [Government of West Bengal, 2009].

Kolkata has the highest vehicular density per km among all Mega- cities of India and normal speed in Kolkata at present is 19 km per hour [Government of West Bengal, 2008]. But there are problems which are worthy to note which disturbs the health profile indirectly.

- Lack of integration of transportation and land use.
- Critical parking conditions, especially in the down town or Central Business District.
- High air pollution and noise level in high traffic density corridor.
- Unsustainable and low capacity road based public transport system.
- High increase of personalized vehicles and unregulated growth of Intermediate Passenger Transport.
- Inadequacy of long term transport plan and programmes. Ad-hoc plans are mostly capital intensive with low return and low gestation period

- Deregulation, privatization and de-investment of public transport undertakings.
- High energy consumption [Government of India, 2010].

VIII. THE MAIN DRAWBACKS

Inadequate and poor quality of public transport has led to increasing use of personalized vehicles [Bhaduri Sukla, 2008]. Roads in the cities have inadequate facilities for pedestrians, cyclists and cycle rickshaws; pavements are fast disappearing and even where they exist, they have been transformed to parking places for private vehicles. Vehicle ownership in these cities has increased with rising household income, aspiration for better quality of life, enabling a market environment for vehicle purchase, increasing trip lengths and inadequate public transport system. The heavy concentration of private motor vehicles in metropolitan cities has been one of the key reasons for congestion, increased travel times, pollution and accidents. The improved approach for easy traffic flow, cleaner air, better fuel technology [Infrastructure Development Finance Company Ltd., 2008] the following are some of the options that can be taken –

- Reduction in private vehicles on road
- Increase in public transport and non motorized rider ship
- Cleaner vehicle fleet

These in turn would have a significant impact on the energy consumption levels and CO₂ emissions produced. Again analysis of daily Respiratory Particulate Matter (RPM) data at different monitoring stations based on United States Environmental Protection Agency (USEPA) air quality index indicated that 80 per cent of the days of the year RPM levels at the monitoring stations located at residential areas remained at safe level while at major traffic intersection points reaches at alarming situation which may cause serious health impact on exposed population [Government of West Bengal, 2011].

IX. KEY PLANS

It is important that the cities in India recognize energy use and CO₂ emissions from their transport sector as well as other transport emissions and Kolkata is no exception. As a key issue of concern, it is demanding immediate and proactive action. Urban transport plans and projects need to be viewed from these perspectives.

- A better transport planning with modal shift to public transport
- Extensive public transport facilities and non-motorized modes in urban areas in order to discourage personalized vehicles.
- Clean fuel, retiring old polluting vehicles, promoting use of electric vehicles and use of mass transport system

- Integrated land-use planning, public transport at its maximum and non motorized transport (NMT) in cities should be given thrust.

Like all other metropolitan cities, Kolkata also needs a better traffic management programmes to reduce the air pollution syndrome. Kolkata city can reduce the air pollution by either increasing the road capacity or by reducing the traffic (demand). The following are some of the options for better management of air quality in Kolkata city:

- New construction of roads and flyovers together with expansion of road width
- Reducing the traffic demand
- Congestion pricing
- Road space rationing
- Increasing road infrastructure
- Proper traffic management
- One way road system to improve the vehicular speed
- Use of public mode of transport
- Vertical parkways must be designed to increase road space
- Separation of lanes for user groups
- A manual or uniform traffic control device standards
- Limitation on car license issue
- Restricting slow moving vehicles on major transit routes
- Removal of hawkers from the footways
- Banning all meetings and processions on weekdays

X. FINDINGS AND CONCLUDING OBSERVATION

During the observation following points have been notified:

- 100 per cent of the major roads have traffic gridlock [Government of West Bengal, 2013].
- Congestion within the core area has greatly affected the trade and business along with major environmental impact on quality of life.
- Pedestrian fatalities have increased and the sidewalks have been choked by car parking.
- Frequency of electricity operated Tram service has been drastically reduced.
- The spending on health cost has increased multifold.
- It is better to limit the number of personalized vehicles especially two wheelers and four wheelers because these emit more pollutants in the environs of Kolkata.
- Frequency of buses should be increased to cover the regular distance, otherwise increasing number of vehicles are not adequate in proportion to road space within the city of Kolkata.
- Poor quality of fuel must be banned whereas Liquid Petroleum Gas and Compressed Natural Gas must be encouraged to reduce automobile emission.
- Strict order and regulations should be maintained to ban the encroachment on the side of road and as it has been notified that catalytic converter engine

reduce the emission, so motor vehicles department in collaboration with West Bengal Pollution Control Board must implement catalytic converter engines in all the newly launched vehicles under West Bengal Surface Transport Corporation, Calcutta State Transport Corporation, Calcutta Tramways Company and Jawaharlal Nehru National Urban Renewal Mission.

- Phasing out of 15 years of old or more engine vehicles from the city of Kolkata should be looked upon as it emits more and create traffic congestions [Government of West Bengal, 2011].
- Optimization of traffic and improvement in traffic management must be followed to increase the speed of the vehicles which would reduce vehicular emission at end. Traffic management programme includes Global Positioning System regulated navigation and traffic signaling system, green corridors, removal of encroachment of roads, regulation on digging roads for various purposes etc [Government of West Bengal, 2009].
- Improvement of vehicle technology is another systematic approach to reduce emission followed by restriction on manufacturing of two stroke engine [Government of India, 2001].
- In order to minimize disruptions and congestion created by the on street parking, special attention is needed to: [Government of West Bengal, 2010]
 - Maximize the width of carriageway;
 - Select the location of on street parking space;
 - Select the location of on street parking lots on major arterial roads and transit corridors;
 - Delineate the on street parking lots with proper traffic signals signs and road markings;
 - Provide the engines, emission warranty and on board diagnostic system.

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Sukla Bhaduri obtained her post graduate degree from the University of Calcutta in 1972 and she was awarded Ph.D. degree by the same University in 1982. She did her Post Doctoral research in the Centre for Urban Economics Studies affiliated to the University of Calcutta. She has served University of Burdwan from 1991 to 1997 and joined the University of Calcutta in 1997. At present she

is Professor of Geography and a member of the Ph.D. Committee of the discipline. Her areas of interest include Urban and Transport Geography, Environmental Geography and Social Geography. She has published as many as 20 major papers in reputed journal and edited books. She is the author of two books and editor of two other books. She has participated in 55 national and international conferences / seminars. She has successfully supervised 15 Ph.D. theses so far and conducted one ICSSR sponsored and another UGC sponsored research projects. At present she is the Chairperson of the Under Graduate Board of Studies in Geography in the University of Calcutta and member of the Ph.D. Committee of Geography in three other State Universities of West Bengal.