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# Determination of carbon monoxide (CO) concentration and emission from various traffic vehicles of Raipur region

**Shobhana Ramteke[1], Bharat Lal Sahu[2*]**
[1] School of Studies in Environmental Science, Pt. Ravishankar Shukla University, Raipur, Chhattisgarh, India
[2] Department of Chemistry, Guru Ghasidas Central University, Bilaspur, Chhattisgarh, India

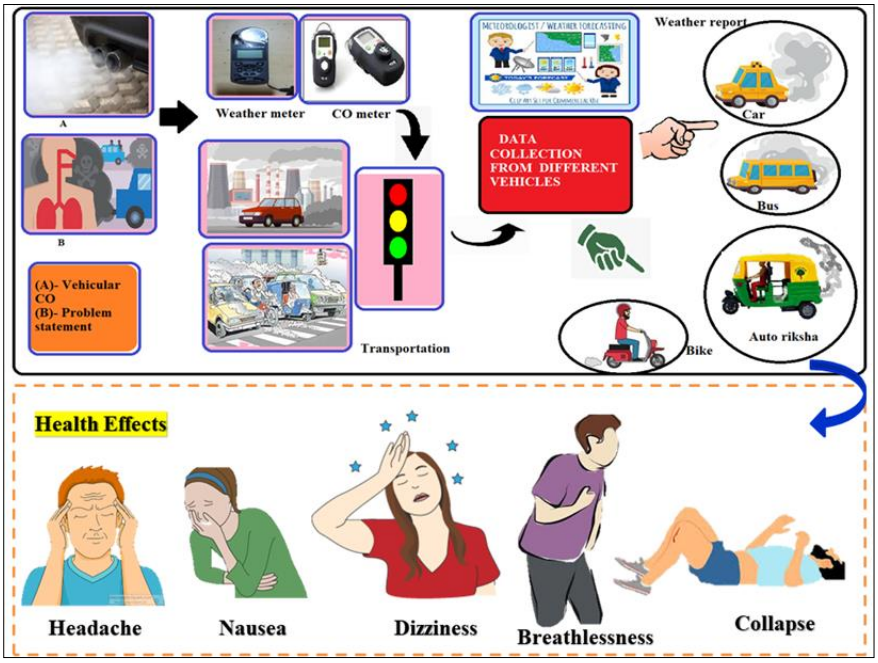
**Abstract**
The increase of traffic flow in cities causes traffic congestion and accidents as well as air pollution. Traffic problems have attracted the interest of many researchers from the perspective of theory and engineering. In order to provide a simple and practical method for measuring the exhaust emission and assessing the effect of pollution control, a model is based on the relationship between traffic flow and vehicle exhaust emission under a certain level of road capacity constraints. In the proposed model, the hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NO) are considered as the indexes of total exhaust emission, and the speed is used as an intermediate variable. To verify the rationality and practicality of the model, a case study for Beijing, China, is provided in which the effects of taxi fare regulation and the specific vehicle emission reduction policy are analyzed.

**Keywords:** health effects, carbon monoxide, traffic vehicles

## Introduction
Carbon monoxide (CO) is a tasteless, odorless and colorless gas. It is a by-product of partial combustion of organic compounds [1]. Although general fires, charcoal stove emissions, LPG fueled portable heater emissions account for the majority of reported CO poisoning fatalities, with about one third of CO poisoning cases resulting in death stem from gasoline motor exhaust emissions. [2] These cases are often associated with malfunctioning or clogged motor vehicle exhaust systems but also, to a lesser extent, with CO induced suicide attempts. In addition, tobacco products consumption is considered a significant source of CO poisoning in humans. The negative impact of urban road traffic is mainly on-air quality [3], ecosystem, and noise level [4]. Due to the continuing increase of motor vehicles, human health and environment have been severely impacted. According to the classification of air pollutant sources in urban area, motor vehicle emission accounts for more than 80% of the air pollution in major cities [5]. The statistics of Beijing show that the level of carbon monoxide and nitrogen oxides exceeds national standard even in the city's fourth and fifth ring roads where the average speed of vehicles is high. Since the concept of sustainable development has been adopted into the theory and methods of urban transport systems planning, the coordination between transportation development and urban environment becomes the focus of the urban transportation research in the 21st century. In recent years, many scholars have studied vehicle exhaust emission for environment protection [6-10]. The lethal consequences of CO in engine exhaust is tragically illustrated by the hundreds of persons who die each year from carbon monoxide poisoning caused by a running vehicle inside a closed garage. Others die or become ill in homes with attached garages, while stranded in their car, or while driving or riding in a vehicle with a defective exhaust system [11-14]. Motor vehicle emissions standards stated that all vehicles produced after the exploit of norms have to be compliant with the regulations. At present, Bharat Stage IV (BS IV) parallel to Euro IV regulations since April 1st, 2010 is applicable for various types of vehicles; India has recognized limits on CO exposures (at idle) for motorcycles, cars and innovative emission standards for gasoline-fueled cars took effective in 1991 [15]. The automobile emissions are affected by driving pattern; overcrowding, temperature, traffic speed, vehicle's engine conditions and emissions control equipment and its maintenance [16-20]. EPA and WHO has recommended exposure of ambient air quality guideline values for CO at 9 ppm and 25 ppm as an 8 h and 1 h time-weighted avg. concentration respectively. The exhaust pollutants regulations of CO emissions from various countries is represented in India as two wheelers as 0.5gm/km, Four wheelers (Petrol engine) 1.25 gm/km, Four wheelers (Diesel engine) 1.00 gm/km, Six wheelers (Petrol engine) 2.20 gm/km and Six Wheelers (Diesel engine) 2.20 gm/km. [21-25].

## Materials and Methods
### Study area
The traffic vehicular, emissions generate significant amounts of particulates in ambient air of Raipur city of India, causing climate, environmental and health impacts [26]. Raipur (21º23′ N, 81.63E) is a capital of

Chhattisgarh state with population of approximately two million. It is located near the center of a large plain, and its vicinity is becoming an important regional commercial and industrial locale for coal, power, steel and aluminum industries. At least 1000 steel rolling mills, sponge iron plants, steel foundries, metal-alloy plants, agro-industries, and plastic industries are running in and around the city. Thirty-eight samples were detected from various vehicular emissions i.e. 2-Wheeler, Car, Bus, auto from the transportation locations and Forty-four samples from different bike and Car from various department of Pt. Ravishankar Shukla University, Raipur CG to see the comparison of the emission of carbon monoxide from different vehicles in morning and evening. See Figure 1. Carbon monoxide CO is been used for the sampling detection and the meteorological weather meter for the various parameters such as Temperature (T)., Humidity (H)., Wind Speed (WS)., Heat Bulb (HB)., and Wet Bulb (WB) etc.




**Fig**

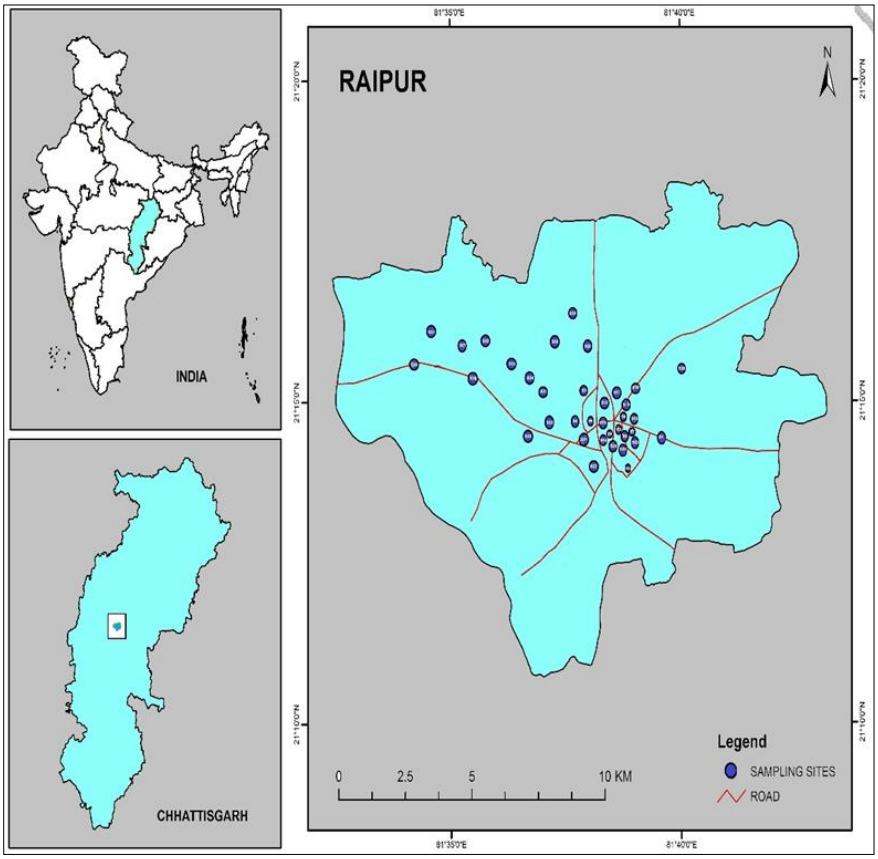



**Fig 1:** Representation of the sampling location of the Raipur city

**Methodology**

The methodology of the study represents the noise level in 38 major locations in Raipur city and 44 from the Pt. Ravishankar Shukla University Campus itself from various traffic emissions such as car, auto, bus and 2 wheelers. These major areas include industrial areas, commercial areas, passenger loading parks, busy roads and junctions. The readings were taken using the CO meter and weather meter. Measurements were taken two different times of the day; morning (10 am to 12 pm), and evening (5 pm to 8 pm). Particularly, the carbon monoxide concentration was considered and analyzed in this present research.

**Results and Discussion**

**CO concentration from vehicles and traffic in morning**

The concentration of the carbon monoxide in the various vehicular emission in the morning session is summarized in Table 1. The Total concentration of the 2W, Auto, Car and Bus are 5690, 15595, 19139, 27732 ppm respectively. The minimum and Maximum value of the 2Wheeler, Auto, Car and Bus are 11-650, 44-951, 140-1150 and 250-1250 ppm respectively with the mean value 149.7±44.3, 410.4±86.4, 503.7±79.9 and 729.8±87.4 ppm respectively. The highest concentration of Carbon monoxide is been found in Bus. See Figure 2.

**Table 1:** CO Concentration in morning from vehicular emission, ppm

| S. No | Date | Location | Time | 2W | Auto | Car | Bus |
|---|---|---|---|---|---|---|---|
| 1 | 10/17/2020 | RC | 11:07 | 67 | 150 | 140 | 300 |
| 2 | 2/17/2020 | KU | 11:14 | 24 | 170 | 200 | 370 |
| 3 | 2/17/2020 | BH | 11:22 | 50 | 320 | 500 | 700 |
| 4 | 2/17/2020 | RR | 11:28 | 90 | 285 | 400 | 670 |
| 5 | 2/17/2020 | PN | 11:35 | 85 | 350 | 600 | 900 |
| 6 | 2/17/2020 | TN | 11:38 | 500 | 360 | 386 | 400 |
| 7 | 2/17/2020 | IC | 11:43 | 80 | 250 | 420 | 700 |
| 8 | 2/17/2020 | KN | 11:47 | 210 | 500 | 370 | 800 |
| 9 | 2/17/2020 | RW | 11:53 | 215 | 386 | 700 | 1000 |
| 10 | 2/17/2020 | TC | 11:56 | 58 | 658 | 285 | 865 |
| 11 | 2/19/2020 | TK | 11:41 | 90 | 700 | 600 | 400 |
| 12 | 2/19/2020 | PG | 11:46 | 155 | 800 | 695 | 500 |
| 13 | 2/19/2020 | KC | 11:52 | 70 | 89 | 400 | 250 |
| 14 | 2/19/2020 | BO | 11:56 | 49 | 300 | 700 | 1001 |
| 15 | 2/19/2020 | JC | 12:04 | 67 | 572 | 670 | 900 |
| 16 | 2/19/2020 | GC | 12:17 | 320 | 720 | 490 | 870 |
| 17 | 2/19/2020 | MC | 12:22 | 270 | 690 | 520 | 800 |
| 18 | 2/19/2020 | PBS | 12:29 | 650 | 720 | 900 | 1150 |
| 19 | 2/19/2020 | KH | 12:37 | 450 | 872 | 1150 | 1110 |
| 20 | 2/19/2020 | RS | 12:48 | 375 | 720 | 800 | 1250 |
| 21 | 2/20/2020 | LN | 10:38 | 11 | 44 | 150 | 711 |
| 22 | 2/20/2020 | BG | 10:47 | 28 | 90 | 700 | 500 |
| 23 | 2/20/2020 | AC | 11:08 | 95 | 170 | 250 | 600 |
| 24 | 2/20/2020 | MT | 11:12 | 70 | 951 | 600 | 270 |
| 25 | 2/20/2020 | MHT | 11:17 | 95 | 200 | 370 | 600 |
| 26 | 2/22/2020 | AM | 11:41 | 97 | 179 | 275 | 652 |
| 27 | 2/22/2020 | NIT | 11:46 | 81 | 270 | 317 | 450 |
| 28 | 2/22/2020 | CL | 11:51 | 90 | 170 | 250 | 320 |
| 29 | 2/22/2020 | AP | 11:57 | 85 | 178 | 320 | 950 |
| 30 | 2/22/2020 | GO | 10:44 | 130 | 109 | 331 | 501 |
| 31 | 2/22/2020 | MB | 11:11 | 85 | 71 | 252 | 902 |
| 32 | 2/22/2020 | TT | 11:18 | 120 | 890 | 981 | 1011 |
| 33 | 2/22/2020 | SA | 11:25 | 159 | 200 | 442 | 670 |
| 34 | 2/22/2020 | RSU | 11:37 | 109 | 317 | 502 | 750 |
| 35 | 2/22/2020 | BMC | 11:07 | 150 | 368 | 265 | 768 |
| 36 | 2/22/2020 | GG | 11:14 | 89 | 654 | 543 | 1245 |
| 37 | 2/22/2020 | HC | 11:22 | 165 | 798 | 1098 | 987 |
| 38 | 2/22/2020 | RAM | 11:28 | 156 | 324 | 567 | 909 |

**CO Concentration from vehicles in evening**

The concentration of the carbon monoxide in the various vehicular emission in the morning session is summarized in Table 2. The Total concentration of the 2W, Auto, Car and Bus are 4508, 14969, 17806, 22515 ppm respectively. The minimum and Maximum value of the 2Wheeler, Auto, car and Bus are 20-400, 100-910, 100-987 and 234-1365 ppm respectively, with the mean value 118.6±24.9, 393.9±74.9, 468.6±71.5 and

592.5±92.8 ppm respectively. The highest concentration of Carbon monoxide is been found in all the vehicular emission. See Figure 2.

**Table 2:** CO Concentration in Evening from Vehicular emission.

| S. No | Date | Location | Time | 2W | Auto | Car | Bus |
|---|---|---|---|---|---|---|---|
| 1 | 10/17/2020 | RC | 4:01 | 82 | 278 | 249 | 400 |
| 2 | 2/17/2020 | KU | 4:09 | 80 | 250 | 300 | 480 |
| 3 | 2/17/2020 | BH | 4:15 | 75 | 450 | 600 | 800 |
| 4 | 2/17/2020 | RR | 4:20 | 100 | 400 | 720 | 1010 |
| 5 | 2/17/2020 | PN | 4:26 | 78 | 500 | 960 | 1100 |
| 6 | 2/17/2020 | TN | 4:29 | 400 | 295 | 600 | 900 |
| 7 | 2/17/2020 | IC | 4:33 | 90 | 429 | 500 | 829 |
| 8 | 2/17/2020 | KN | 4:36 | 300 | 600 | 490 | 300 |
| 9 | 2/17/2020 | RW | 4:42 | 252 | 300 | 900 | 800 |
| 10 | 2/17/2020 | TC | 4:48 | 95 | 400 | 289 | 990 |
| 11 | 2/19/2020 | TK | 4:09 | 75 | 910 | 320 | 400 |
| 12 | 2/19/2020 | PG | 4:13 | 95 | 156 | 320 | 601 |
| 13 | 2/19/2020 | KC | 4:15 | 80 | 101 | 500 | 600 |
| 14 | 2/19/2020 | BO | 4:17 | 89 | 250 | 750 | 290 |
| 15 | 2/19/2020 | JC | 4:23 | 80 | 361 | 420 | 501 |
| 16 | 2/19/2020 | GC | 4:26 | 201 | 300 | 502 | 400 |
| 17 | 2/19/2020 | MC | 4:30 | 101 | 701 | 500 | 407 |
| 18 | 2/19/2020 | PBS | 4:34 | 250 | 600 | 366 | 306 |
| 19 | 2/19/2020 | KH | 4:38 | 250 | 800 | 100 | 720 |
| 20 | 2/19/2020 | RS | 4:48 | 201 | 800 | 600 | 620 |
| 21 | 2/20/2020 | LN | 3:59 | 20 | 711 | 450 | 360 |
| 22 | 2/20/2020 | BG | 4:05 | 50 | 159 | 700 | 317 |
| 23 | 2/20/2020 | AC | 4:23 | 80 | 120 | 270 | 300 |
| 24 | 2/20/2020 | MT | 4:26 | 90 | 170 | 300 | 400 |
| 25 | 2/20/2020 | MHT | 4:30 | 79 | 187 | 320 | 310 |
| 26 | 2/22/2020 | AM | 4:17 | 89 | 187 | 285 | 610 |
| 27 | 2/22/2020 | NIT | 4:21 | 75 | 190 | 287 | 389 |
| 28 | 2/22/2020 | CL | 4:36 | 99 | 190 | 375 | 470 |
| 29 | 2/22/2020 | AP | 4:30 | 90 | 179 | 285 | 470 |
| 30 | 2/22/2020 | GO | 4:07 | 102 | 701 | 370 | 490 |
| 31 | 2/22/2020 | MB | 3:47 | 87 | 100 | 119 | 502 |
| 32 | 2/22/2020 | TT | 3:53 | 98 | 720 | 450 | 670 |
| 33 | 2/22/2020 | SA | 3:59 | 79 | 170 | 320 | 449 |
| 34 | 2/22/2020 | RSU | 4:14 | 80 | 129 | 285 | 390 |
| 35 | 2/22/2020 | BMC | 4:01 | 98 | 600 | 432 | 234 |
| 36 | 2/22/2020 | GG | 4:09 | 75 | 432 | 987 | 1123 |
| 37 | 2/22/2020 | HC | 4:15 | 76 | 456 | 895 | 1365 |
| 38 | 2/22/2020 | RAM | 4:20 | 167 | 687 | 690 | 1212 |

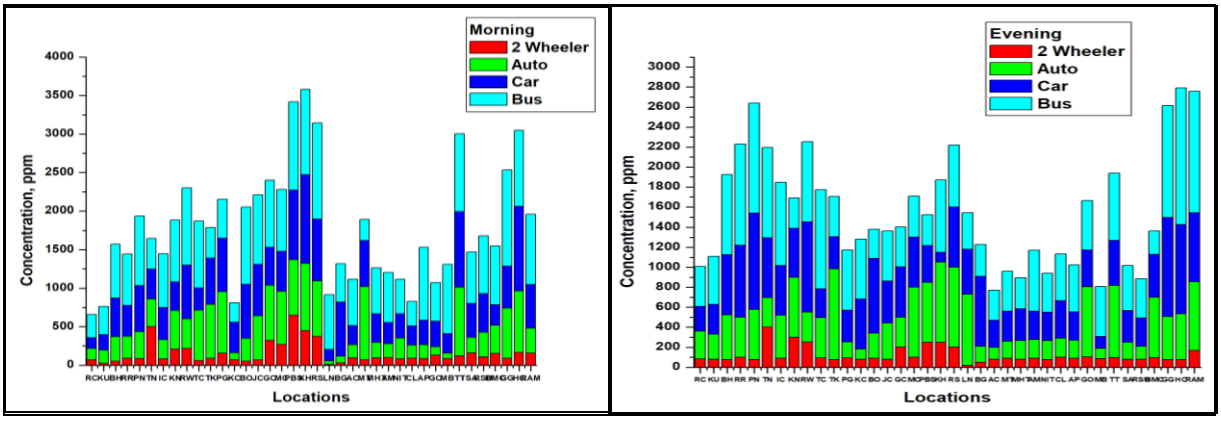



**Fig 2:** CO Concentration of Vehicular emission in morning and evening.

**Meteorological parameters of CO in morning**

The meteorological parameters for the study period are summarized in (Table-3). The Temperature, Wind speed, Humidity, Heat Index and Wet Bulb for the study period ranged from 80-94 ºC, 0.7-2.4 km $h^{-1}$, 28 -53.9 %, 80.2-98.1 and 63.9-73.9 mm, respectively with mean value of 88.8 ºC, 1.14 km $h^{-1}$, 37.44 %, 90.57 mm, 69.16 mm, respectively. The concentration of CO was remarkably higher (> 1.4-2.2 folds) in the Railway Station and Jaistamb Chowk with different vehicular emission of the city (Table-3). Figure 3

**Table 3:** Meteorological parameters of CO monitoring in morning

| S. No | Date | Location | Temp (ºC) | Wind Speed (km/h) | Humidity (%) | Heat Index (mm) | Wet Bulb (mm) |
|---|---|---|---|---|---|---|---|
| 1 | 10/17/2020 | RC | 86.4 | 0.9 | 33.2 | 86.7 | 67.5 |
| 2 | 2/17/2020 | KU | 90.5 | 1 | 28.9 | 90.5 | 67.8 |
| 3 | 2/17/2020 | BH | 90.8 | 1.1 | 29.7 | 91.8 | 68.7 |
| 4 | 2/17/2020 | RR | 88.5 | 1 | 30 | 86.4 | 65.7 |
| 5 | 2/17/2020 | PN | 85.8 | 0.8 | 31 | 86.7 | 65.5 |
| 6 | 2/17/2020 | TN | 91.4 | 1.1 | 29.9 | 92.1 | 68.9 |
| 7 | 2/17/2020 | IC | 88.9 | 2 | 28.9 | 88 | 66.7 |
| 8 | 2/17/2020 | KN | 88 | 0.9 | 28.9 | 86.4 | 65.5 |
| 9 | 2/17/2020 | RW | 85.3 | 1 | 31.5 | 83.1 | 63.9 |
| 10 | 2/17/2020 | TC | 85 | 1.1 | 31.9 | 83.1 | 64.6 |
| 11 | 2/19/2020 | TK | 87.2 | 1.1 | 31 | 84.6 | 64.6 |
| 12 | 2/19/2020 | PG | 89.4 | 0.9 | 32 | 88.7 | 67.1 |
| 13 | 2/19/2020 | KC | 89.7 | 0.9 | 32.8 | 90.7 | 68.5 |
| 14 | 2/19/2020 | BO | 89.8 | 0.8 | 31.8 | 90.1 | 68 |
| 15 | 2/19/2020 | JC | 89.4 | 0.7 | 32.9 | 89.6 | 67.9 |
| 16 | 2/19/2020 | GC | 93.9 | 1.1 | 29.9 | 95.5 | 70.2 |
| 17 | 2/19/2020 | MC | 92.5 | 1 | 30.6 | 93.7 | 69.1 |
| 18 | 2/19/2020 | PBS | 93.3 | 0.9 | 33.4 | 95.5 | 70 |
| 19 | 2/19/2020 | KH | 91.2 | 1.6 | 31.1 | 93.6 | 70.2 |
| 20 | 2/19/2020 | RS | 94.6 | 0.7 | 28.9 | 95.2 | 68.9 |
| 21 | 2/20/2020 | LN | 80.9 | 1.6 | 44.7 | 80.2 | 66.6 |
| 22 | 2/20/2020 | BG | 82.5 | 1.9 | 43.9 | 81.3 | 66.2 |
| 23 | 2/20/2020 | AC | 84.9 | 2.4 | 43 | 85.5 | 68.2 |
| 24 | 2/20/2020 | MT | 87.4 | 1.1 | 42.7 | 89.8 | 70.7 |
| 25 | 2/20/2020 | MHT | 89.2 | 1.1 | 40.9 | 93.4 | 72.3 |
| 26 | 2/22/2020 | AM | 91 | 1.3 | 43.2 | 96.1 | 73 |
| 27 | 2/22/2020 | NIT | 88.6 | 1 | 41.9 | 93.4 | 71.8 |
| 28 | 2/22/2020 | CL | 92 | 0.9 | 40.5 | 98.1 | 73.9 |
| 29 | 2/22/2020 | AP | 91.6 | 1.3 | 41.2 | 96 | 73.2 |
| 30 | 2/22/2020 | GO | 82.7 | 0.9 | 53.9 | 85.5 | 70.3 |
| 31 | 2/22/2020 | MB | 85.9 | 2.4 | 46.5 | 88.7 | 70.5 |
| 32 | 2/22/2020 | TT | 87.3 | 1 | 47.3 | 92.5 | 73 |
| 33 | 2/22/2020 | SA | 89.2 | 1.2 | 44 | 94.5 | 73 |
| 34 | 2/22/2020 | RSU | 87.1 | 1 | 43.8 | 89.9 | 70.9 |
| 35 | 2/22/2020 | BMC | 87.6 | 1 | 46.5 | 96 | 71.8 |
| 36 | 2/22/2020 | GG | 91.6 | 0.8 | 45.9 | 98.1 | 73 |
| 37 | 2/22/2020 | HC | 93.4 | 1 | 53.6 | 96.5 | 73 |
| 38 | 2/22/2020 | RAM | 92.6 | 1 | 40.9 | 94.3 | 67.3 |

**Meteorological parameters of CO in Evening**

The meteorological parameters for the study period are summarized in (Table-4). The temperature, Wind speed, Humidity, Heat Index and Wet Bulb for the study period ranged from 80-93 ºC, 0.2-1.7 km $h^{-1}$, 27 -43.8 %, 82.-96.4 and 63.3-73.2 mm, respectively with mean value of 89.06 ºC, 1.05 km $h^{-1}$, 34.87 %, 90.40 mm, 68.49, respectively. The concentration of CO was remarkably higher (> 1.4-2.2 folds) in the Railway Station and Jaistamb Chowk with different vehicular emission of the city and as compare to the evening data has highest concentration. (Table-4). Figure 3.

**Table 4:** Meteorological parameters of CO monitoring in Evening.

| S. No | Date | Location | Temp (ºC) | Wind Speed (km/h) | Humidity (%) | Heat Index (mm) | Wet Bulb (mm) |
|---|---|---|---|---|---|---|---|
| **1** | 10/17/2020 | RC | 89.5 | 1.1 | 29 | 89.4 | 67.6 |
| 2 | 2/17/2020 | KU | 80.2 | 1.1 | 28.7 | 87.1 | 65.5 |
| 3 | 2/17/2020 | BH | 87.5 | 1.1 | 29.9 | 85.1 | 64.8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 4 | 2/17/2020 | RR | 87.9 | 0.9 | 29.7 | 86 | 65.1 |
| 5 | 2/17/2020 | PN | 87 | 0.2 | 30.2 | 84.3 | 65.1 |
| 6 | 2/17/2020 | TN | 86.7 | 1 | 30 | 84.4 | 64.4 |
| 7 | 2/17/2020 | IC | 87.1 | 1.6 | 28.8 | 84.9 | 64.9 |
| 8 | 2/17/2020 | KN | 87.1 | 0.8 | 30 | 84.6 | 64.4 |
| 9 | 2/17/2020 | RW | 85.2 | 0.9 | 29.1 | 82.6 | 63.3 |
| 10 | 2/17/2020 | TC | 85.7 | 1 | 30 | 83.5 | 64.2 |
| 11 | 2/19/2020 | TK | 86.1 | 1 | 32.1 | 86.5 | 63.5 |
| 12 | 2/19/2020 | PG | 87.6 | 1 | 33.1 | 87.2 | 68.1 |
| 13 | 2/19/2020 | KC | 86.6 | 0.8 | 31.7 | 89.6 | 67.2 |
| 14 | 2/19/2020 | BO | 87.2 | 0.9 | 32.7 | 87.1 | 64 |
| 15 | 2/19/2020 | JC | 87.3 | 1 | 34.8 | 86.2 | 66.8 |
| 16 | 2/19/2020 | GC | 92.9 | 1 | 30.1 | 94.6 | 70 |
| 17 | 2/19/2020 | MC | 91.5 | 1.1 | 32.5 | 93 | 67.1 |
| 18 | 2/19/2020 | PBS | 92.2 | 1 | 34 | 94.5 | 70.1 |
| 19 | 2/19/2020 | KH | 90.1 | 1 | 32.1 | 92.6 | 70.1 |
| 20 | 2/19/2020 | RS | 93.2 | 0.6 | 27.8 | 94.1 | 67.8 |
| 21 | 2/20/2020 | LN | 92 | 0.9 | 31.5 | 93.2 | 69.4 |
| 22 | 2/20/2020 | BG | 89.2 | 1.7 | 33.5 | 89.4 | 68.2 |
| 23 | 2/20/2020 | AC | 89.2 | 0.9 | 35.4 | 89.8 | 68.7 |
| 24 | 2/20/2020 | MT | 90.3 | 1 | 34.7 | 91.6 | 69.3 |
| 25 | 2/20/2020 | MHT | 91.3 | 1 | 33.5 | 92.5 | 69.4 |
| 26 | 2/22/2020 | AM | 90.6 | 0.8 | 43.8 | 90 | 72.3 |
| 27 | 2/22/2020 | NIT | 90.1 | 0.9 | 40.4 | 93.2 | 71.2 |
| 28 | 2/22/2020 | CL | 90.4 | 1 | 40.8 | 94.6 | 72.1 |
| 29 | 2/22/2020 | AP | 89.8 | 1.4 | 41 | 92.7 | 70.9 |
| 30 | 2/22/2020 | GO | 90.7 | 1.6 | 41.6 | 96.4 | 73.2 |
| 31 | 2/22/2020 | MB | 89.1 | 1.4 | 43.6 | 93 | 72.1 |
| 32 | 2/22/2020 | TT | 90.9 | 1.6 | 41 | 95.5 | 72.3 |
| 33 | 2/22/2020 | SA | 91.2 | 0.8 | 40.7 | 95.9 | 72.9 |
| 34 | 2/22/2020 | RSU | 90 | 1 | 40.6 | 92.8 | 70.9 |
| 35 | 2/22/2020 | BMC | 91.3 | 1 | 40.9 | 95.6 | 70.6 |
| 36 | 2/22/2020 | GG | 89 | 0.9 | 40.6 | 93.2 | 70 |
| 37 | 2/22/2020 | HC | 90.7 | 1.4 | 41.2 | 94.9 | 72.1 |
| 38 | 2/22/2020 | RAM | 89.8 | 1.6 | 43.8 | 93.5 | 73 |

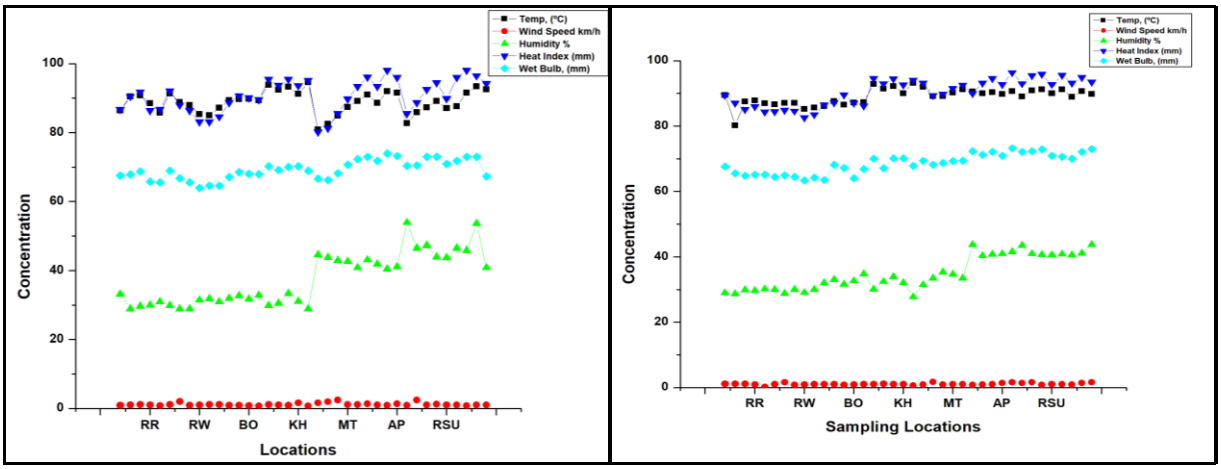



**Fig 3:** Meteorological parameter for traffic emission in morning and evening.

**CO Concentration of Bike and Car emission from Pt. R S U Campus Morning**

The concentration of the carbon monoxide in the various vehicular emission in the morning session is summarized in Table 5. The Total concentration of the Bike and Car are ranged from 4087 and 11436 ppm respectively. The minimum and Maximum value of the Bike and Car are 13-900 and 17-833 ppm respectively, with the mean value 92.89±49.55 and 259.91±69.47 ppm respectively. The highest concentration of Carbon monoxide is been found in car in the morning time. See Figure 4.

**Table 5:** CO monitoring from Pt R S U campus in morning, ppm

| S. No | Date | Location | Time | Bike | Car |
|---|---|---|---|---|---|
| 1 | 2/10/2020 | CD | 11:17 | 500 | 450 |
| 2 | 2/10/2020 | ART | 11:30 | 90 | 200 |
| 3 | 2/10/2020 | LI | 11:42 | 99 | 100 |
| 4 | 2/10/2020 | EL | 11:53 | 73 | 140 |
| 5 | 2/11/2020 | PH | 11:16 | 19 | 189 |
| 6 | 2/11/2020 | AU | 11:23 | 22 | 180 |
| 7 | 2/11/2020 | GE | 11:29 | 49 | 63 |
| 8 | 2/11/2020 | AUD | 11:38 | 54 | 44 |
| 9 | 2/11/2020 | BS | 11:45 | 96 | 104 |
| 10 | 2/11/2020 | PO | 11:50 | 20 | 311 |
| 11 | 2/11/2020 | MN | 11:56 | 28 | 602 |
| 12 | 2/11/2020 | SW | 12:01 | 22 | 833 |
| 13 | 2/11/2020 | BT | 12:10 | 39 | 170 |
| 14 | 2/11/2020 | PE | 12:15 | 24 | 601 |
| 15 | 2/12/2020 | PD | 11:20 | 17 | 128 |
| 16 | 2/12/2020 | LS | 11:28 | 15 | 74 |
| 17 | 2/12/2020 | GL | 11:32 | 42 | 91 |
| 18 | 2/12/2020 | MT | 11:38 | 19 | 36 |
| 19 | 2/12/2020 | LD | 11:43 | 29 | 37 |
| 20 | 2/12/2020 | PH | 11:49 | 21 | 185 |
| 21 | 2/12/2020 | RS | 11:54 | 16 | 372 |
| 22 | 2/12/2020 | PP | 11:58 | 13 | 100 |
| 23 | 2/12/2020 | GH | 12:03 | 18 | 71 |
| 24 | 2/12/2020 | AD B | 12:10 | 17 | 82 |
| 25 | 2/13/2020 | HC | 12:11 | 15 | 119 |
| 26 | 2/13/2020 | AH | 12:15 | 17 | 120 |
| 27 | 2/13/2020 | BRH | 12:18 | 20 | 35 |
| 28 | 2/13/2020 | ST, SC Centre | 12:22 | 28 | 130 |
| 29 | 2/13/2020 | CG RHGA | 12:27 | 31 | 631 |
| 30 | 2/13/2020 | HRDC | 12:36 | 20 | 17 |
| 31 | 2/13/2020 | CS & IT | 12:39 | 13 | 75 |
| 32 | 2/13/2020 | BM | 12:46 | 16 | 82 |
| 33 | 2/14/2020 | PGH | 11:16 | 25 | 600 |
| 34 | 2/14/2020 | GH | 11:22 | 22 | 271 |
| 35 | 2/14/2020 | TH | 11:25 | 15 | 181 |
| 36 | 2/14/2020 | ENS | 11:29 | 24 | 200 |
| 37 | 2/14/2020 | IGNOU | 11:32 | 70 | 320 |
| 38 | 2/14/2020 | TC | 11:38 | 18 | 121 |
| 39 | 2/14/2020 | GH | 11:41 | 330 | 700 |
| 40 | 2/14/2020 | KRS | 11:47 | 300 | 600 |
| 41 | 2/14/2020 | LF | 11:56 | 280 | 671 |
| 42 | 2/14/2020 | VS | 12:55 | 220 | 580 |
| 43 | 2/14/2020 | KR | 1:06 | 381 | 700 |
| 44 | 2/14/2020 | EVS | 1:11 | 900 | 120 |

**CO Concentration of Bike and Car emission from Pt. R S U campus (Evening)**

The concentration of the carbon monoxide in the various vehicular emission in the morning session is summarized in Table 6. The Total concentration of the Bike and Car from Pt. Ravishankar Shukla Campus are 2308 and 11985 ppm respectively. The minimum and Maximum value of the Bike and Car are ranged from 10-387 and 13-937 ppm respectively, with the mean value 52±24.7, and 272±77.2 ppm respectively. The highest concentration of Carbon monoxide is been found in Bus. See Figure 5.

**Table 6:** CO monitoring from Pt R S U campus in evening, ppm

| S. No | Date | Location | Time | Bike | Car |
|---|---|---|---|---|---|
| 1 | 2/10/2020 | CD | 4:18 | 20 | 200 |
| 2 | 2/10/2020 | ART | 4:27 | 373 | 185 |
| 3 | 2/10/2020 | LI | 4:35 | 10 | 150 |
| 4 | 2/10/2020 | EL | 4:41 | 28 | 80 |
| 5 | 2/11/2020 | PH | 4:05 | 23 | 180 |

| | | | | | |
|---|---|---|---|---|---|
| 6 | 2/11/2020 | AU | 4:10 | 27 | 139 |
| 7 | 2/11/2020 | GE | 4:15 | 73 | 317 |
| 8 | 2/11/2020 | AUD | 4:20 | 10 | 130 |
| 9 | 2/11/2020 | BS | 4:25 | 37 | 217 |
| 10 | 2/11/2020 | PO | 4:30 | 38 | 580 |
| 11 | 2/11/2020 | MN | 4:35 | 28 | 608 |
| 12 | 2/11/2020 | SW | 4:40 | 14 | 514 |
| 13 | 2/11/2020 | BT | 4:45 | 13 | 59 |
| 14 | 2/11/2020 | PE | 4:52 | 12 | 156 |
| 15 | 2/12/2020 | PD | 4:04 | 13 | 30 |
| 16 | 2/12/2020 | LS | 4:10 | 28 | 24 |
| 17 | 2/12/2020 | GL | 4:15 | 70 | 25 |
| 18 | 2/12/2020 | MT | 4:18 | 18 | 19 |
| 19 | 2/12/2020 | LD | 4:26 | 14 | 23 |
| 20 | 2/12/2020 | PH | 4:30 | 13 | 93 |
| 21 | 2/12/2020 | RS | 4:34 | 18 | 13 |
| 22 | 2/12/2020 | PP | 4:37 | 28 | 19 |
| 23 | 2/12/2020 | GH | 4:41 | 17 | 15 |
| 24 | 2/12/2020 | AD B | 4:48 | 15 | 17 |
| 25 | 2/13/2020 | HC | 4:11 | 25 | 85 |
| 26 | 2/13/2020 | AH | 4:15 | 20 | 90 |
| 27 | 2/13/2020 | BRH | 4:18 | 80 | 174 |
| 28 | 2/13/2020 | ST, SC Centre | 4:22 | 18 | 138 |
| 29 | 2/13/2020 | CG RHGA | 4:26 | 16 | 173 |
| 30 | 2/13/2020 | HRDC | 4:34 | 18 | 226 |
| 31 | 2/13/2020 | CS & IT | 4:36 | 41 | 423 |
| 32 | 2/13/2020 | BM | 4:44 | 13 | 340 |
| 33 | 2/14/2020 | PGH | 4:12 | 270 | 900 |
| 34 | 2/14/2020 | GH | 4:16 | 38 | 300 |
| 35 | 2/14/2020 | TH | 4:19 | 87 | 470 |
| 36 | 2/14/2020 | ENS | 4:21 | 24 | 790 |
| 37 | 2/14/2020 | IGNOU | 4:24 | 21 | 700 |
| 38 | 2/14/2020 | TC | 4:27 | 34 | 287 |
| 39 | 2/14/2020 | GH | 4:29 | 31 | 500 |
| 40 | 2/14/2020 | KRS | 4:32 | 87 | 300 |
| 41 | 2/14/2020 | LF | 4:35 | 32 | 307 |
| 42 | 2/14/2020 | VS | 4:39 | 39 | 177 |
| 43 | 2/14/2020 | KR | 4:42 | 87 | 875 |
| 44 | 2/10/2020 | EVS | 4:46 | 387 | 937 |

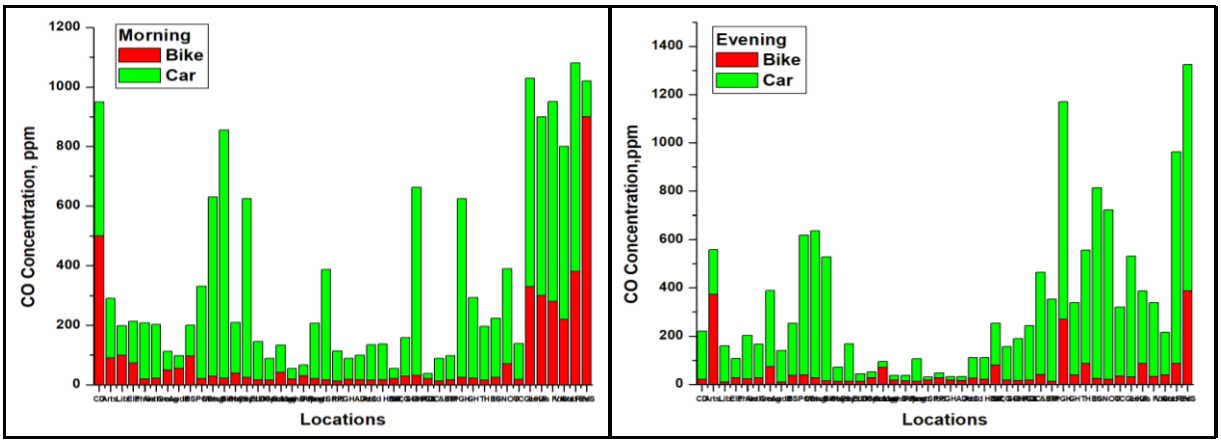



**Fig 4:** CO emission in Car from morning and evening session.

**Meteorological parameters of CO from Pt. R S U in Morning**

The meteorological parameters for the study period are summarized in (Table-7). The Temperature, Wind speed, Humidity, Heat Index and Wet Bulb for the study period ranged from 76.2-92.4 ºC, 0.8-4.1 km $h^{-1}$, 26 -73.4 %, 72.-96.6 and 62.4-72.3 mm, respectively with mean value of 84.67 ºC, 1.41 km $h^{-1}$, 39.08 %, 84.64 mm, 67.05, respectively. The concentration of CO was remarkably higher (> 1.4-2.2 folds) in the with different vehicular emission of the city and as compare to the evening data has highest concentration. (Table-7). Figure 6.

**Table 7:** Meterological parameters for CO in morning for Pt R S U Campus

| S. No | Date | Location | Temp (ºC) | Wind Speed (km/h) | Humidity (%) | Heat Index (mm) | Wet Bulb (mm) |
|---|---|---|---|---|---|---|---|
| 1 | 2/10/2020 | CD | 76.2 | 4.1 | 50.1 | 72.9 | 64.9 |
| 2 | 2/10/2020 | ART | 76.3 | 1.9 | 46.4 | 74.5 | 62.6 |
| 3 | 2/10/2020 | LI | 77 | 1.2 | 73.4 | 74.8 | 72.1 |
| 4 | 2/10/2020 | EL | 79 | 1.4 | 38 | 76.8 | 62.4 |
| 5 | 2/11/2020 | PH | 78.5 | 0.8 | 44.7 | 78.3 | 64.8 |
| 6 | 2/11/2020 | AU | 79.5 | 1.5 | 44.3 | 81.7 | 67.1 |
| 7 | 2/11/2020 | GE | 83.2 | 2.1 | 41.6 | 83.8 | 68.2 |
| 8 | 2/11/2020 | AUD | 83.4 | 0.9 | 39.7 | 81.9 | 64.8 |
| 9 | 2/11/2020 | BS | 83.6 | 1.4 | 39.1 | 83.3 | 66.9 |
| 10 | 2/11/2020 | PO | 82.9 | 0.9 | 38 | 80.6 | 64.4 |
| 11 | 2/11/2020 | MN | 82 | 1.1 | 38.4 | 78.6 | 63.9 |
| 12 | 2/11/2020 | SW | 81.6 | 1.2 | 40.6 | 82 | 66.6 |
| 13 | 2/11/2020 | BT | 85.2 | 0.8 | 38.9 | 85.6 | 67.1 |
| 14 | 2/11/2020 | PE | 84.7 | 0.9 | 36.9 | 83.3 | 66.1 |
| 15 | 2/11/2020 | PD | 80.1 | 0.9 | 44.6 | 80.4 | 66 |
| 16 | 2/12/2020 | LS | 81.5 | 1.4 | 42.3 | 82.4 | 66.7 |
| 17 | 2/12/2020 | GL | 81.5 | 1.4 | 42.3 | 82.4 | 66.7 |
| 18 | 2/12/2020 | MT | 83.1 | 1.4 | 40.2 | 82.6 | 65.5 |
| 19 | 2/12/2020 | LD | 83.8 | 1.3 | 39.3 | 82.8 | 65.8 |
| 20 | 2/12/2020 | PH | 86.3 | 1.2 | 42.2 | 86.7 | 68.2 |
| 21 | 2/12/2020 | RS | 85.2 | 1.4 | 38.9 | 86.2 | 68.5 |
| 22 | 2/12/2020 | PP | 84.1 | 0.9 | 40.7 | 84 | 66.9 |
| 23 | 2/12/2020 | GH | 85 | 1.1 | 40 | 85.2 | 68.5 |
| 24 | 2/12/2020 | AD B | 82.1 | 1 | 39.4 | 79.2 | 64 |
| 25 | 2/12/2020 | HC | 81.4 | 0.9 | 39.9 | 79.7 | 64.2 |
| 26 | 2/13/2020 | AH | 82.5 | 1.1 | 31.3 | 80.8 | 63.1 |
| 27 | 2/13/2020 | BRH | 85 | 1 | 30.7 | 81.5 | 63 |
| 28 | 2/13/2020 | ST, SC Centre | 89.1 | 0.9 | 33.6 | 91.6 | 69.1 |
| 29 | 2/13/2020 | CG RHGA | 91 | 1 | 29.8 | 90.7 | 67.8 |
| 30 | 2/13/2020 | HRDC | 90.4 | 1.3 | 29 | 91.2 | 69.6 |
| 31 | 2/13/2020 | CS & IT | 91.2 | 0.9 | 26.8 | 88.3 | 65 |
| 32 | 2/13/2020 | BM | 91.6 | 1.8 | 26 | 92.5 | 67 |
| 33 | 2/13/2020 | PGH | 88.9 | 1.9 | 27.4 | 90.9 | 67.8 |
| 34 | 2/14/2020 | GH | 85.1 | 2.1 | 41.1 | 87.4 | 69.3 |
| 35 | 2/14/2020 | TH | 85.4 | 1.1 | 39.5 | 87.3 | 68.9 |
| 36 | 2/14/2020 | ENS | 86.8 | 1.9 | 39.7 | 87.1 | 68.2 |
| 37 | 2/14/2020 | IGNOU | 86.1 | 2.3 | 39.6 | 86.2 | 67.6 |
| 38 | 2/14/2020 | TC | 88.1 | 1.5 | 38 | 90.1 | 70 |
| 39 | 2/14/2020 | GH | 92.4 | 1.3 | 35.9 | 96.6 | 72.3 |
| 40 | 2/14/2020 | KRS | 87.3 | 1.7 | 38 | 87.6 | 68.4 |
| 41 | 2/14/2020 | LF | 89.2 | 2.2 | 37.7 | 93.7 | 71.1 |
| 42 | 2/14/2020 | VS | 86.8 | 2.6 | 37.3 | 87.4 | 68.2 |
| 43 | 2/14/2020 | KR | 86.1 | 1.1 | 42.6 | 87.6 | 69.4 |
| 44 | 2/14/2020 | EVS | 88.6 | 1.5 | 39 | 89.4 | 69.1 |

**Meteorological parameters of CO from Pt. R S U in Evening**

The meteorological parameters for the study period are summarized in (Table-8). The Temperature, Wind speed, Humidity, Heat Index and Wet Bulb for the study period ranged from 75-97 ºC, 0.6-2.2 km $h^{-1}$, 33 -47.7 %, 73.9-95.7 and 61-70.2 mm, respectively with mean value of 82 ºC, 1 km $h^{-1}$, 40 %, 81 mm, 65 respectively. The concentration of CO was remarkably higher (> 1.4-2.2 folds) in the Car vehicular emission with different vehicular emission of the city and as compare to the evening data has highest concentration. (Table-8). Figure 7.

**Table 8:** Meterological parameters for CO in evening from Pt. R S U campus

| S. No | Date | Location | Temp (ºC) | Wind Speed (km/h) | Humidity (%) | Heat Index (mm) | Wet Bulb (mm) |
|---|---|---|---|---|---|---|---|
| 1 | 2/10/2020 | CD | 76.1 | 0.9 | 42.9 | 74.3 | 61.2 |
| 2 | 2/10/2020 | ART | 75.9 | 1 | 43.5 | 73.9 | 61 |
| 3 | 2/10/2020 | LI | 76.8 | 0.8 | 42.1 | 74.7 | 61.2 |
| 4 | 2/10/2020 | EL | 75.8 | 1.2 | 47.7 | 74.3 | 62.1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 2/11/2020 | PH | 77.5 | 1.3 | 42.8 | 75.6 | 62.2 |
| 6 | 2/11/2020 | AU | 80.1 | 1 | 41.5 | 79.2 | 64.9 |
| 7 | 2/11/2020 | GE | 79.9 | 1.6 | 38.1 | 77.7 | 62.4 |
| 8 | 2/11/2020 | AUD | 80.1 | 0.9 | 39 | 77.9 | 63 |
| 9 | 2/11/2020 | BS | 79.4 | 1 | 41.2 | 77.7 | 63.5 |
| 10 | 2/11/2020 | PO | 81.4 | 0.8 | 42.8 | 80.2 | 64.8 |
| 11 | 2/11/2020 | MN | 79.4 | 0.6 | 42.3 | 78.3 | 64.2 |
| 12 | 2/11/2020 | SW | 81.1 | 1 | 39 | 79.7 | 64 |
| 13 | 2/11/2020 | BT | 81.5 | 1.2 | 42.3 | 80.1 | 65.3 |
| 14 | 2/11/2020 | PE | 79.1 | 2.2 | 41.1 | 77.2 | 63 |
| 15 | 2/12/2020 | PD | 82.5 | 1 | 43.6 | 78.6 | 65.1 |
| 16 | 2/12/2020 | LS | 78.8 | 1.4 | 45.3 | 77.5 | 64 |
| 17 | 2/12/2020 | GL | 79.9 | 1 | 44.1 | 78.8 | 64.6 |
| 18 | 2/12/2020 | MT | 79.6 | 0.9 | 44.4 | 78.4 | 64.4 |
| 19 | 2/12/2020 | LD | 80 | 1.1 | 43 | 78.6 | 64.6 |
| 20 | 2/12/2020 | PH | 79.9 | 0.8 | 42.3 | 78.6 | 64 |
| 21 | 2/12/2020 | RS | 79.9 | 1 | 43.5 | 78.8 | 64.8 |
| 22 | 2/12/2020 | PP | 80.9 | 1.8 | 41.1 | 80.2 | 65.1 |
| 23 | 2/12/2020 | GH | 81.3 | 1 | 42.8 | 80.2 | 65.5 |
| 24 | 2/12/2020 | AD B | 78.5 | 1.1 | 44.4 | 78.1 | 64.8 |
| 25 | 2/13/2020 | HC | 80.2 | 0.7 | 42.9 | 79 | 64.4 |
| 26 | 2/13/2020 | AH | 80.4 | 1 | 40.8 | 79.5 | 64.9 |
| 27 | 2/13/2020 | BRH | 79.4 | 1.6 | 42.7 | 78.4 | 64.6 |
| 28 | 2/13/2020 | ST, SC Centre | 82 | 0.8 | 39.6 | 80.2 | 64.8 |
| 29 | 2/13/2020 | CG RHGA | 83.2 | 1.2 | 36.6 | 81.1 | 63.7 |
| 30 | 2/13/2020 | HRDC | 83.6 | 1.2 | 35.7 | 82.4 | 65.3 |
| 31 | 2/13/2020 | CS & IT | 84.9 | 1.2 | 33.1 | 83.3 | 64.8 |
| 32 | 2/13/2020 | BM | 84.4 | 0.9 | 37 | 83.3 | 65.3 |
| 33 | 2/14/2020 | PGH | 81.9 | 1 | 39.1 | 81 | 65.5 |
| 34 | 2/14/2020 | GH | 86.1 | 1.4 | 40.1 | 87.3 | 68.9 |
| 35 | 2/14/2020 | TH | 87.4 | 1.7 | 36.7 | 87.8 | 68 |
| 36 | 2/14/2020 | ENS | 88 | 1.1 | 35.8 | 87.6 | 67.6 |
| 37 | 2/14/2020 | IGNOU | 88.3 | 1 | 36 | 88.7 | 68.2 |
| 38 | 2/14/2020 | TC | 89.2 | 1.2 | 36.1 | 89.6 | 68.5 |
| 39 | 2/14/2020 | GH | 90.2 | 1.2 | 34.8 | 95.7 | 70.2 |
| 40 | 2/14/2020 | KRS | 87.5 | 1.3 | 36.1 | 87.4 | 67.8 |
| 41 | 2/14/2020 | LF | 97.5 | 0.9 | 37.2 | 87.8 | 68 |
| 42 | 2/14/2020 | VS | 86.2 | 1.2 | 37.8 | 86.2 | 67.3 |
| 43 | 2/14/2020 | KR | 85.2 | 0.9 | 39.1 | 85.1 | 66.9 |
| 44 | 2/14/2020 | EVS | 86 | 1.3 | 36.5 | 85.6 | 66.9 |

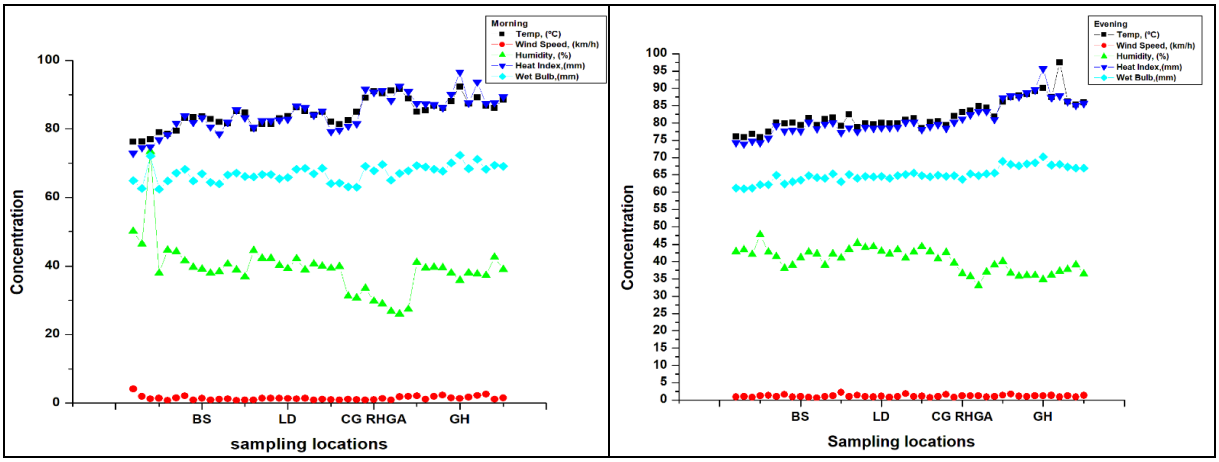
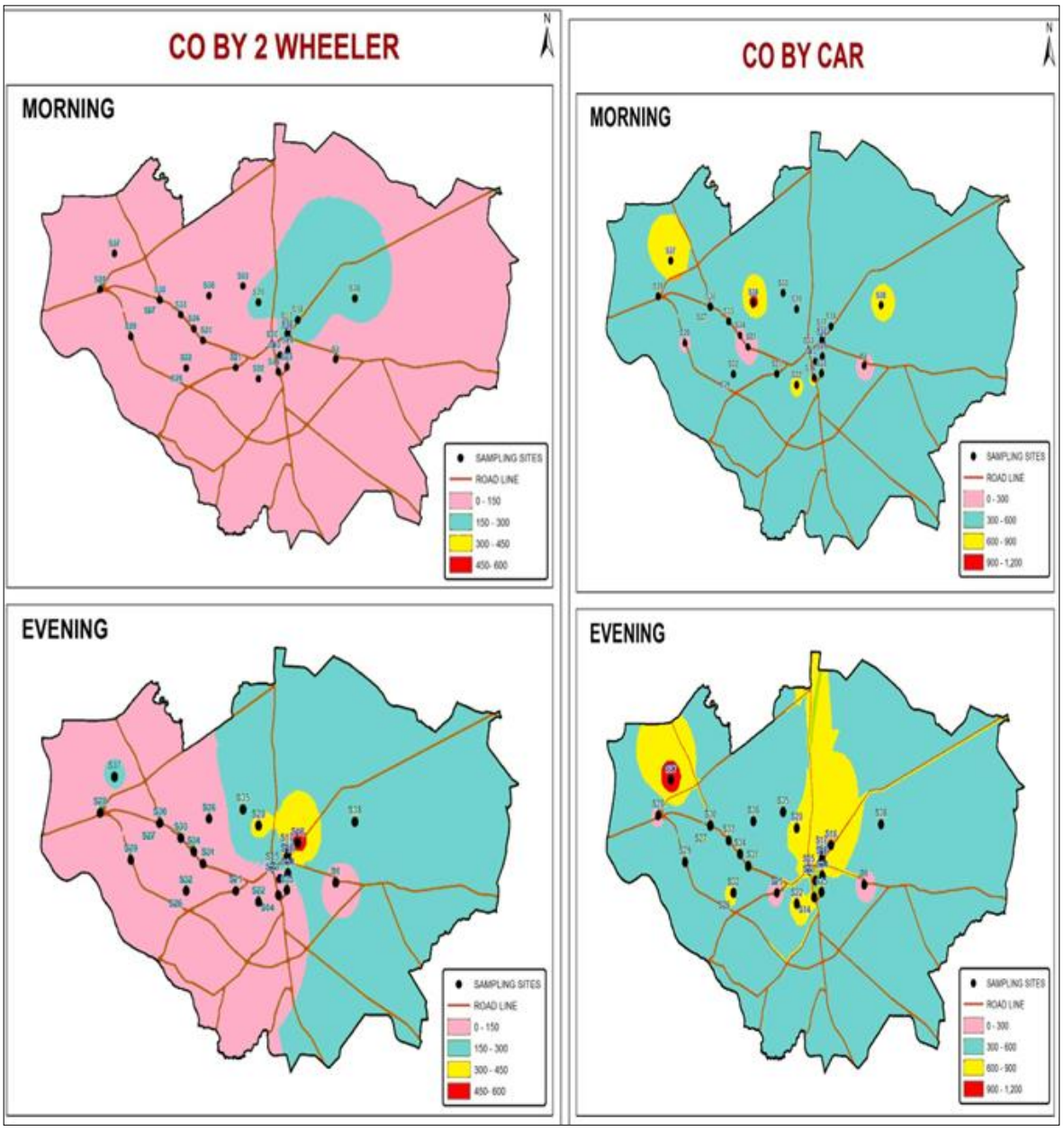



**Fig 5:** Meteorological parameter for the morning and evening.

**CO Modeling for different vehicles**

An open source QGIS (Quantum geographic information system) software was applied to generate prediction maps at different vehicular and traffic emissions a day (**Figure 8 and 9**). The resultant prediction maps showed that the concentrations of traffic CO increased more on evening than on morning time. These maps also showed

that there was significant variation between traffic CO concentrations according to the time of morning as in evening data, with the traffic CO. As it is been indicated in different four range i.e 0-150, 150-300, 300-450, 450 -600 and 800-1200 ppm according to the CO monitoring in various vehicles. As the results indicated that the Concentration of CO is several folds higher than the morning emissions, as more traffic and vehicles run accordingly.



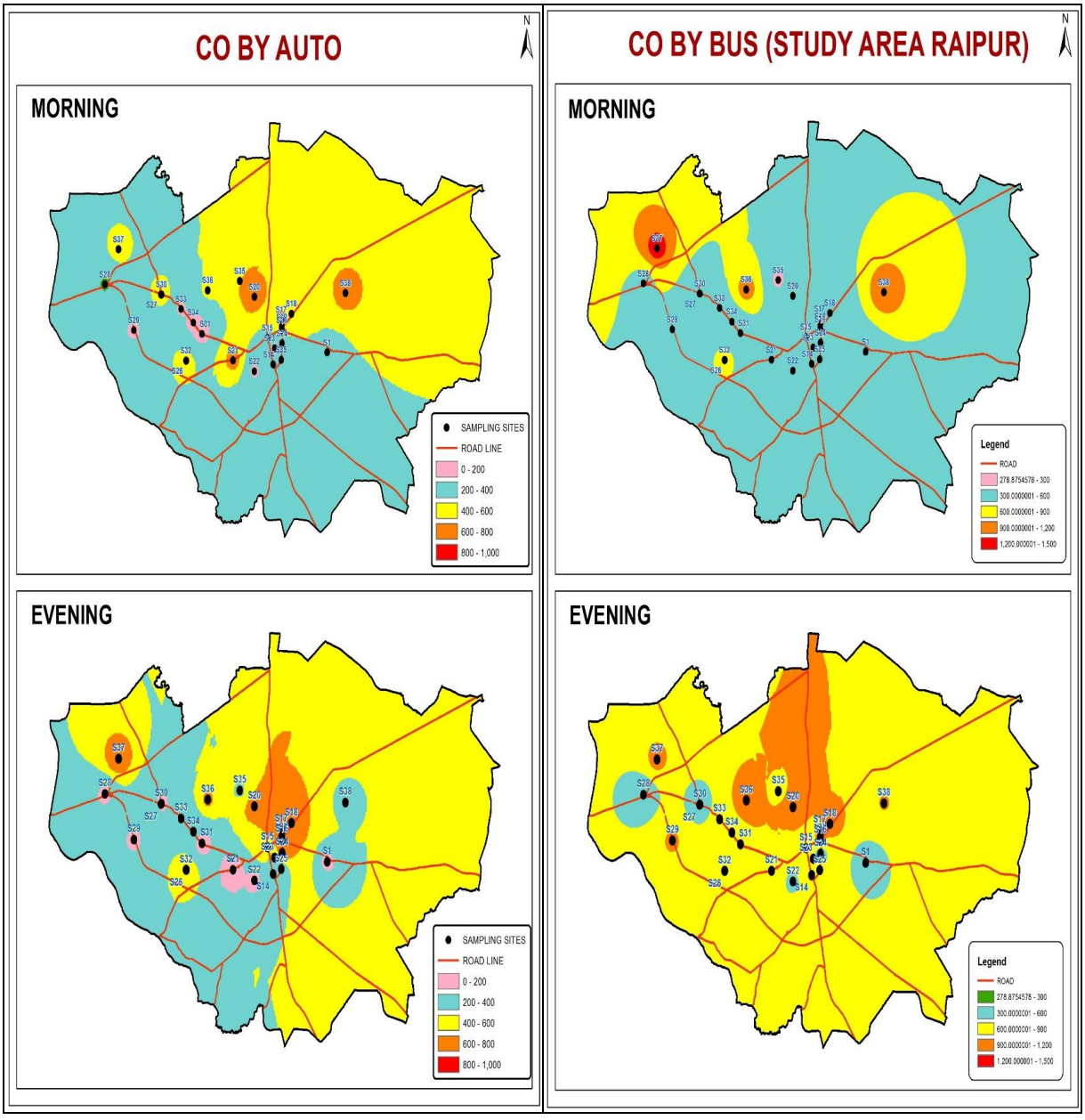



**Fig 6:** CO Modelling for various vehicular emission for 2 wheeler, auto, car and bus.

**CO Modeling from Pt. R S U Car and Bike**

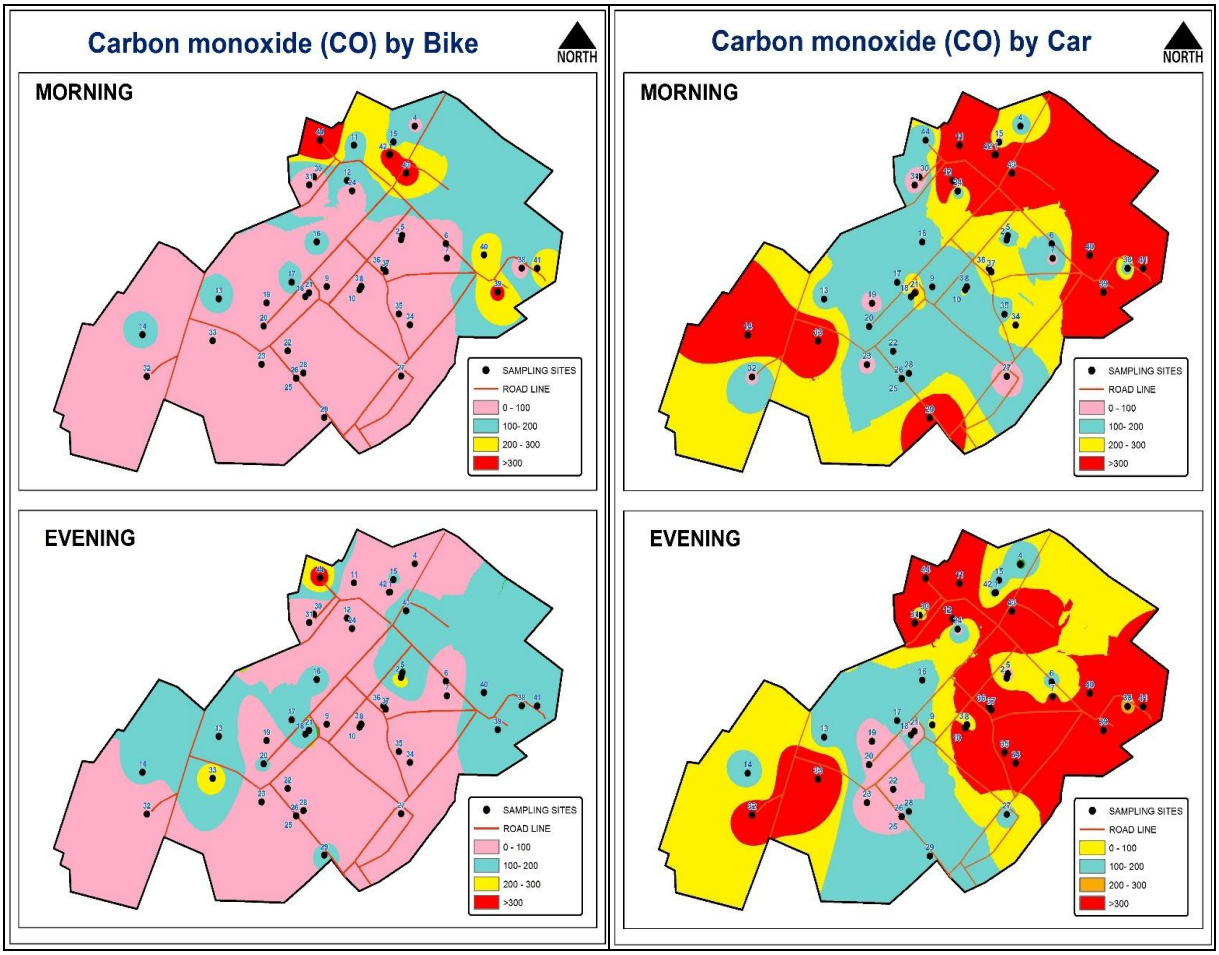



**Fig 7:** CO Modelling for various vehicular emission for Bike and Car from Pt. R S U Campus.

Carbon monoxide is one of the most poisoning gas presents in the atmosphere. It is obvious that the impact of traffic flow on vehicle exhaust emission can be measured in Raipur city congested cities. Therefore, the model is an effective way to control the volume of vehicles on urban roads and improve the speed and efficiency of vehicles to reduce the excessive pollution caused by vehicle emission in Raipur city. In addition to carbon monoxide, hydrocarbons, and nitrogen oxide compounds, particulate matter (PM) measured as either $PM_{10}$ or $PM_{2.5}$ (i.e., PM less than 10 μm or 2.5 μm in diameter, resp.) is also quite harmful to human body.

**References**

1. Prockop LD, Chichkova RI. Carbon monoxide intoxication: an updated review. Journal of Neurological Science,2007:262:122-130.
2. Hoffman RS, Nelson LS, Howland MA, Lewin NA, Flomenbaum NE, Goldfrank LR. Carbon Monoxide. Goldfrank's Manuel of Toxicologic Emergencies, 8th edition. McGraw-Hill, New York, 2007, 151-153.
3. Van Meter KW, Tintinalli JE, Kelen GD, Stapczynski JS. Carbon Monoxide Poisining. Emergency Medicine A Comprehensive Study Guide, 6th edition. McGraw-Hill. New York, NY, 2010, 1238-1241.
4. Kumar P, Ketzel M, Vardoulakis S, Pirjola L, Britter R. Dynamics and dispersion modelling of nanoparticles from road traffic in the urban atmospheric environment - a review, Journal of Aerosol Science,2011:42(9):580-603.
5. Popescu DI, Tuns RE, Moholea IF. The Urban Acoustic Environment–A Survey for Road Traffic Noise. Carpathian Journal of Earth and Environmental Sciences,2011:6(1):285-292.
6. Burr ML, Karani G, Davies B, Holmes BA, Williams KL. Effects on respiratory health of a reduction in air pollution from vehicle exhaust emissions. Occupational and environmental medicine,2004:61(3):212-218.
7. Rhys-Tyler GA, Legassick W, Bell MC. The significance of vehicle emissions standards for levels of exhaust pollution from light vehicles in an urban area. Atmospheric Environment,2011:45(19):3286-3293.
8. Yi K, Wang LZ, Qi BX, Zhang LM, Lei S. Investigation and analysis of motor vehicle exhaust emission in cities. Energy Conversion and Application,2001:1(2):250-253.
9. Schifter I, Diaz L, Avalos S, Vera M, Mejia I, Reyes F, *et al*. Trends of exhaust emissions from gasoline motor vehicles in the metropolitan area of Mexico City. International journal of environment and pollution,2004:21(2):166-174.

10. Alkurdi F, Karabet F, Dimashki M. Characterization, concentrations and emission rates of polycyclic aromatic hydrocarbons in the exhaust emissions from in-service vehicles in Damascus. Atmospheric Research, 120, 68-77.
11. Ropkins K, Beebe J, Li H, Daham B, Tate J, Bell M, *et al*. Real-world vehicle exhaust emissions monitoring: review and critical discussion. Critical Reviews in Environmental Science and Technology,2009:39(2):79-152.
12. May AA, Presto AA, Hennigan CJ, Nguyen NT, Gordon TD, Robinson AL. Gas-particle partitioning of primary organic aerosol emissions:(1) Gasoline vehicle exhaust. Atmospheric Environment,2013:77:128-139.
13. Mikulcic H, Von Berg E, Vujanovic M, Priesching P, Tatschl R, Duic N. Numerical analysis of cement calciner fuel efficiency and pollutant emissions. Clean technologies and environmental policy,2013:15(3):489- 499.
14. Fulper CR, Kishan S, Baldauf RW, Sabisch M, Warila J, Fujita EM, *et al*. Methods of characterizing the distribution of exhaust emissions from light-duty, gasoline-powered motor vehicles in the US fleet. Journal of the Air & Waste Management Association,2010:60(11):1376-1387.
15. Baum MM, Moss JA, Pastel SH, Poskrebyshev GA. Hydrogen cyanide exhausts emissions from in-use motor vehicles. Environmental science & technology,2007:41(3):857-862.
16. Tu X, Dong F, Qi F, Zhang Y, Liu W, Liu J. On-road remote sensing of CO and CO2 of motor vehicle exhaust emissions in Beijing using a TDLAS system. In Optical Technologies for Atmospheric, Ocean, and Environmental Studies. International Society for Optics and Photonics,2005:58(32):350-358.
17. Margiotta RA. Improved vehicle speed estimation procedures for air quality and planning applications. UMI, Ann Arbor, Mich, 1996.
18. Jimenez-Palacios JL. Understanding and quantifying motor vehicle emissions with vehicle specific power and TILDAS remote sensing. Massachusetts Institute of Technology, 1998.
19. Niu YX, Niu M, Li Y. Application of man-machine-environment system engineering in urban road traffic safety in China, in Proceedings of the 9th Conference on Man-Machine-Environment System Engineering (MMESE '09), Dandong, China, 2009, 282-285.
20. Siebel F, Mauser W, Moutari S, Rascle M. Balanced vehicular traffic at a bottleneck. Mathematical and Computer Modelling,2009:49(3-4):689-702.
21. Smith M, Mailler R. The effect of congestion frequency and saturation on coordinated traffic routing. In International Conference on Principles and Practice of Multi-Agent Systems Springer, Berlin, Heidelberg, 2011, 187-201.
22. Arasan VT, Vedagiri P. Estimation of saturation flow of heterogeneous traffic using computer simulation, in Proceedings of the 20th European Conference on Modelling and Simulation: Modelling Methodologies and Simulation Key Technologies in Academia and Industry, (ECMS ‘06), Bonn, Germany, 2006, 393-398.
23. Singh S, Prasad R. Physico-chemical analysis and study of different parameters of hopcalite catalyst for CO oxidation at ambient temperature. International Journal of Science Engineering Research,2016:7(4):846-855.
24. Kumar GM, Sampath S, Jeena VS, Anjali R. Carbon monoxide pollution levels at environmentally different sites. Journal Industrial Geophysics. Union,2008:12(1):31-40.
25. Badr O, Probert SD. Carbon - monoxide concentration in the Earth's atmosphere. Applied Energy,1994:49(2):99-143.
26. Rudolf W. Concentration of air pollutants inside cars driving on highways and in downtown areas. Science of the total environment,1994:146:433-444.