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Air Quality Prediction Modeling for Dwarka Sector 13-14 Circle, New Delhi, India using Caline 4

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Abstract - *Traffic emissions are predominant source of urban air pollution. Although, new technologies are introduced to regulate the pollution level, however, ever increasing numbers of vehicles, especially at congested urban roadways, causing high level emissions in the vicinity of roadways. Considering the gravity of the situation, the dispersion modeling exercise will provide optimal orientation of the intersection to reduce the trapping of pollutants which can be implemented at planning stage. Dwarka Sector 13-14 Circle has been selected as the study location for the present study. Traffic volume at this circle comprises of Car, Three wheelers and Two wheelers. Cars constitutes about 58.7% and 53.3% of the total traffic volume near Metro view apartment and opposite to Vegas Mall respectively. Three Wheeled vehicles having the least percentage i.e. 1.3% to 1.4% of the total vehicle count. Monitoring stations were set-up at very adjacent to the traffic circle under study and monitoring of PM10, SO2, NO2 and CO have been undertaken. Concentration of pollutants was found well within prescribed standards as due to Covid19 pandemic scenario, only limited commercial activities are operational. The model was run considering the Multi run / Worst case approach. The monitoring results were found slightly higher than the modelled value as model only consider traffic as the pollution source. Higher values of the monitoring can be concluded as long term deposition of the Carbon Monoxide in the atmosphere and horizontal movement of the gaseous pollutant from the nearby emitters like DG set, Parking areas, commercial activities, etc.*

Key Words: **Urban Roadway, Carbon Monoxide, Air Quality Monitoring, Air Quality Prediction Modeling, CALINE 4**

1. INTRODUCTION

Increasing demand for transportations due to economic growth has triggered a boom in the number and use of motor vehicles in Delhi (Capital City of India). The pollutants, such as, respirable particulate matter (RPM) especially PM2.5, nitrogen dioxide (NO2), carbon monoxide (CO) and hydrocarbons (HC) are emitted directly by vehicles in the urban environment. The most affected group is the urban inhabitants, especially, the population residing in vicinity of the urban roadways as well as the pedestrians. The situation further deteriorates at the urban roadways, where the ventilation is insufficient.

The CPCB has reported that the share of automobile emissions in air pollution of Delhi has increased over the years to 72 percent.

Traffic emissions are predominant source of urban air pollution. Although, new technologies are introduced to regulate the pollution level, however, ever increasing numbers of vehicles without modification of the road conditions, especially at congested urban roadways, causing high level emissions in the vicinity of roadways. Considering the gravity of the situation, the dispersion modeling exercise will provide optimal orientation of the intersection to reduce the trapping of pollutants which can be implemented at planning stage. The scope of present study is to undertake Air Dispersion Modeling with Caline 4 model in context of study location.

Feasibility and applicability analysis of the dispersion model was always a matter of high interest among the researchers. Many researchers across the globe has undertaken various studies on feasibility of particular dispersion model. Some of the researches has gone one step ahead and developed their own mathematical models for assessment of the dispersion of the pollutants. In a study, Karim and Matsui (1998) and Karim et at. (1998) developed a computer model consisting of wind distributions, emission dispersion and modified Gaussian equation to identified street canyon and vehicle wake effects on the transport of air pollution from urban road to its microenvironments.

Baijayanta Kumar Majumdar (2009) in his study presents, CALINE 4 offers several advantages over other models and is chosen as the base model for the purpose of developing a modified line source model for a city. Niraj Sharma (2013) undertaken the study on performance evaluation of CALINE 4 model for predicting carbon monoxide (CO) concentrations along an urban highway corridor passing through the city of Delhi also along with Rajni Dhyani (2013) has compared CALINE 4 model predictions between flat and hilly terrains along two road corridors in Solan District in the state of Himachal Pradesh (India). Studies presents that Caline 4 model remain unanswerable for complex terrain algorithms like a hilly stretch, also, model under predict the concentration.

Chadetrik Rout (2015) in his study found that Caline 4 predicted results are satisfactorily in agreement to monitored value.

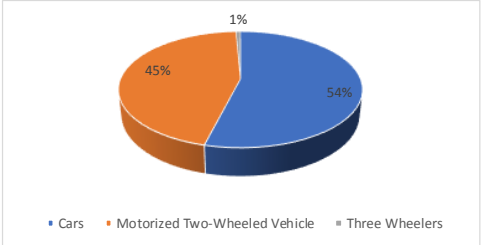
2. MATERIALS AND METHOD

Dwarka Sector 13-14 Circle has been selected as the study location for the present study. The circle receives the traffic from Sector 3, 13, 14 and 17 of Dwarka sub-city. The present road along the circle are in 2 lane configuration and circle provide the signal free crossing. Circle is surrounded by the mix land use with Vegas Multiplex (commercial centre) on one side, Metro View Apartment (residential land use) on other side, third side is having Dwarka Sector 17 Park (open land), whereas, forth side is having open vacant land. Traffic circle is having the circumference of ~188m and radius of the circle is ~30m. The average elevation of the study location is 214m above MSL.

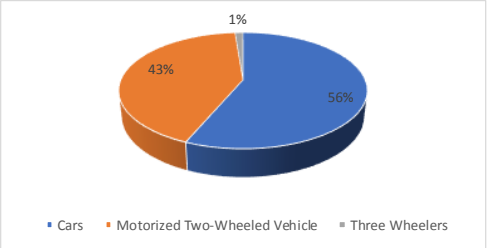
Fig -1: Description of Study Area

Three (3) monitoring stations were set-up at very adjacent to the traffic circle under study and monitoring of Particulate Matter 10 (PM10), Sulphur Di-oxide (SO2), Nitrogen Dioxide (NO2) and Carbon Monoxide (CO) were undertaken. 8 hourly monitoring has been undertaken covering the period from 9am to 5pm. Air quality monitoring was carried continuously for 5 days starting from Tuesday i.e. 15-09-2020 to Saturday i.e. 19-09-2020.

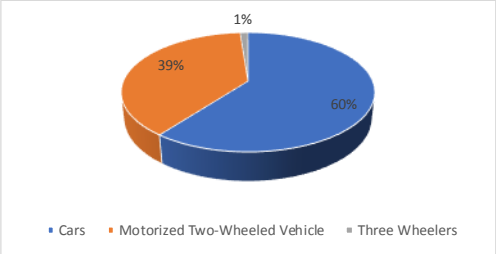
Traffic volume comprises of Car, Three wheelers and Two wheelers. Cars constitutes about 58.7% and 53.3% of the total traffic volume near Metro view apartment and opposite to Vegas Mall respectively. Three Wheeled vehicles having the least percentage i.e. 1.3% to 1.4% of the total vehicle count. Traffic Nos. were found varying from 7372 to 11380 and 6075 to 11148 near Metro View Apartment and Vegas Mall respectively. The composition of traffic volume across different days during the monitoring period is presented in following figures.



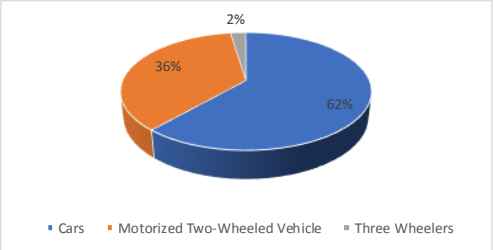
a: Traffic Composition on 15-09-2020



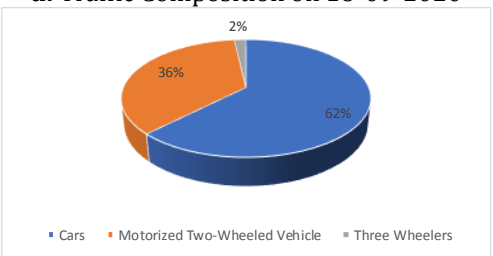
b: Traffic Composition on 16-09-2020



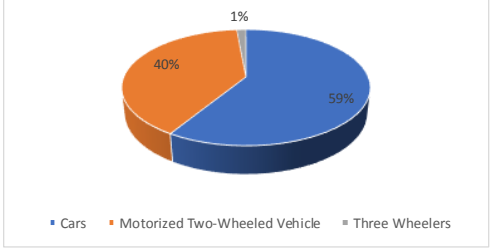
c: Traffic Composition on 17-09-2020



d: Traffic Composition on 18-09-2020

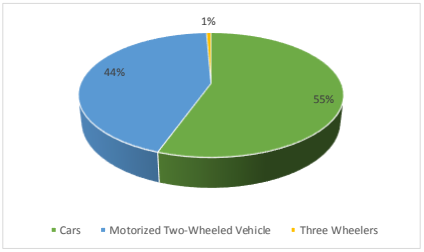


e: Traffic Composition on 19-09-2020

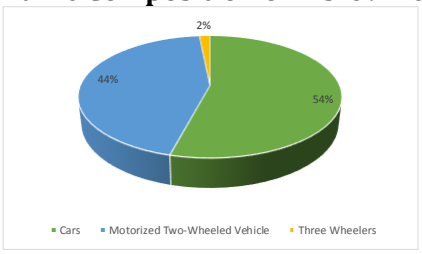


f: Overall Traffic Composition

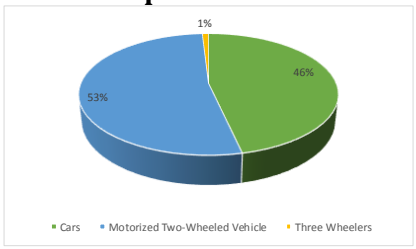
Chart - 1: Traffic Composition near Metro View Apartment



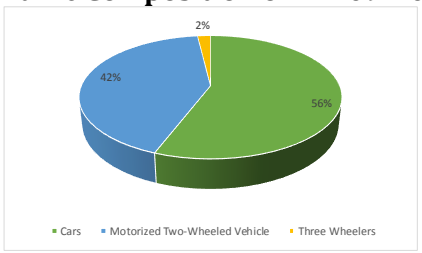
a: Traffic Composition on 15-09-2020



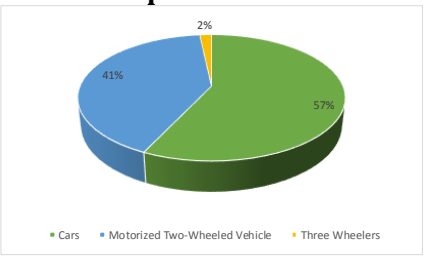
b: Traffic Composition on 16-09-2020



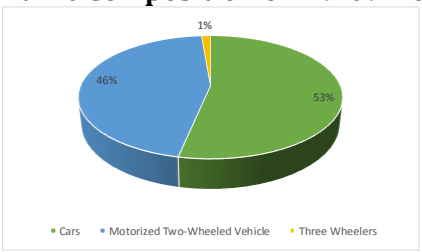
c: Traffic Composition on 17-09-2020



d: Traffic Composition on 18-09-2020



e: Traffic Composition on 19-09-2020



f: Overall Traffic Composition

Chart - 2: Traffic Composition on opposite side of Vegas Mall

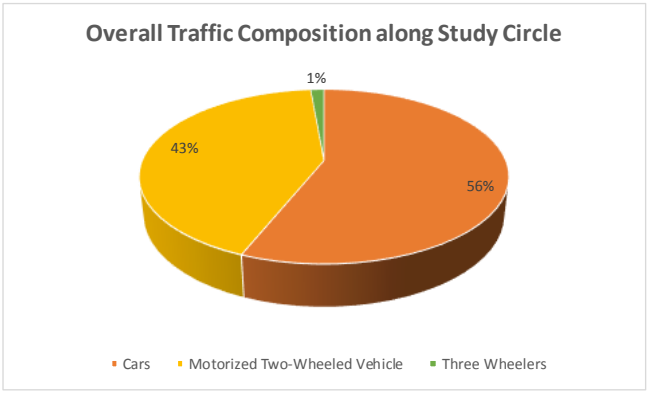


Chart - 3: Overall Traffic Composition in Study Circle

The weighted emission factor was calculated by using the emission factors and corresponding deterioration factors. The weighted emission factor of specified pollutant (gm/km/vehicles) i.e. EW can be estimated as the composite sum of the product of vehicles nos. in specific age group, deterioration factor and emission factor of pollutant divided by total nos. of vehicles recorded. The weighted emission factor was found varying from 2.33 to 2.37 gm/mile/vehicle.

Micro-meteorology data as requisite for model application of Caline 4 includes hourly Wind Speed, Direction, Ambient Temperature, etc. were collected form wunderweather's website for Indira Gandhi International Airport Station. Mixing height were extracted for post-monsoon season from Atlas of Hourly Mixing Height and Assimilative Capacity of Atmosphere in India published by India Meteorological Dept., Govt. of India.

3. RESULTS AND DISCUSSION

Considering the Covid 19 pandemic scenario, the limited commercial activities are supporting the satisfactory level of ambient air pollutant.

The concentration of Particulate matter 10 was found varying from 63 to 84 µg/m3 in respect to the prescribed National Ambient Air Quality Standards of 100 µg/m3 for residential areas. The concentration of SO2 and NO2 were found varying from 5.2 to 6.2 µg/m3 and 10.4 to 12.8 µg/m3 respectively in respect to residential NAAQS limit of 80 µg/m3. The spatial distribution of Carbon Monoxide was found varying from 0.12 to 0.46 mg/m3 in respect to 8 hourly NAAQS of 2 mg/m3. The spatial and temporal variation of the Ambient Air Quality Parameters are presented in Figures below.

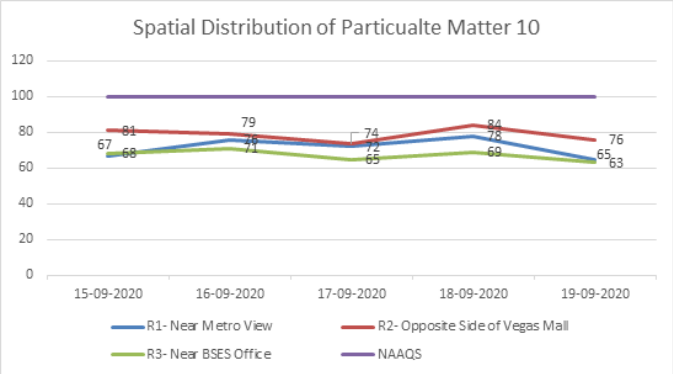


Chart - 4: Temporal and Spatial Distribution of Particulate Matter 10 in µg/m³

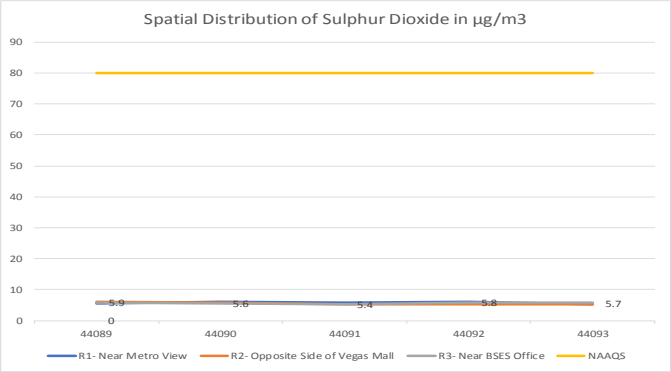


Chart - 5: Temporal and Spatial Distribution of Sulphur Dioxide in µg/m³

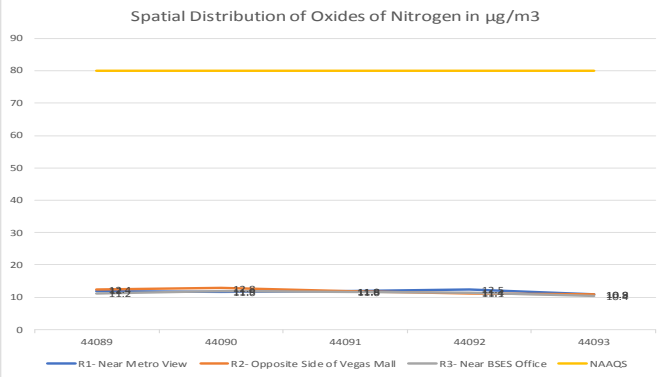


Chart - 6: Temporal and Spatial Distribution of Nitrogen Dioxide in µg/m³

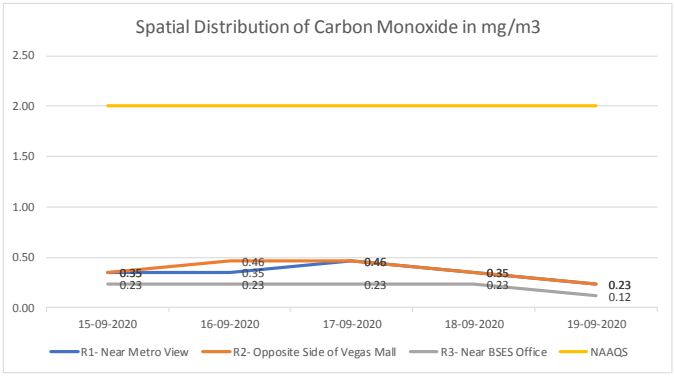


Chart - 7: Temporal and Spatial Distribution of Carbon Monoxide in mg/m³

All the input parameters have been gathered and incorporated in the various tabs on individual input screens for Job Parameters, Rub Conditions, Link Geometry, Link activity and receptors positions. Since the model is window based therefore after incorporation of parameters the run command has been given and the output file has been saved. The model has been run for 8 hourly data (multi run scenario) based on climatological data downloaded from weatherunderground's website.

The model was run considering the Multi run / Worst case approach. In this approach model itself estimate the wind direction for worst case scenario pollution load assessment. This approach negates the variation of prediction due to wind angle.

4. CONCLUSIONS

Predicted results have clear indication that the CO concentration varies significantly with downwind distance from the running traffic and atmospheric conditions. The predicted results were found varying from 0.08 mg/m³ to 0.22 mg/m³ across the receptors. The variation in the predicted concentration is observed due to traffic scenario, distance of the receptors from the traffic point, width of mixing zone and most importantly the meteorological scenario. Calm weather condition supports the least dispersion, which results in higher concentration near to roadways. Scenario was observed in the modeling study undertaken for Saturday i.e. 19th September, 2020. On this day traffic was the least in number, however, calm condition didn't support dispersion of the pollutant. Therefore, highest ever predicted concentration were observed on this day.

The spatial distribution of Carbon Monoxide was found varying from 0.12 to 0.46 mg/m³ in comparison to the predicted concentration of 0.08 to 0.22 mg/m³. The monitoring results were slightly higher than the modelled value. Higher values of the monitoring can be concluded as due to long term deposition of the Carbon Monoxide in the atmosphere and horizontal movement of the gaseous pollutant from the nearby emitters like DG set, Parking areas, commercial activities, etc. as Caline 4 model capability is limited for assessment of traffic generated emission only.

Further, since vehicles contribute significantly to the total air pollution load in most urban areas vehicular pollution control deserves top priority. A practical strategy should be devised that reduces both emissions and congestion, using a mixed set of instruments, which are dictated by command and control, and / or the market-based principles.

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BIOGRAPHIES

Saurabh Kumar Garg has 13+ years of progressive experience in the field of Environment and Social Impact Assessment (ESIA) Studies, formulation of Environment & Social Management and Monitoring Plan / Framework (ESMMP / ESMF), Environment and Social Audit & Due diligence (ESDD), Preparation of Environment and Social Action Plan (ESAP), Air Dispersion Modeling, Noise Modeling, carrying capacity assessment, preparation of Forest Diversion Proposals, Wildlife Clearance / NoC Proposal, etc.