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RESEARCH ARTICLE OPEN ACCESS

Impact Evaluation of Vehicular Emissions on Ambient Air Quality Near Zoological Garden in Mysore city

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ABSTRACT
Human Engineered ecosystem like zoological garden situated next to national highway is continuously exposed to air pollution due to vehicular traffic. Disturbance and pollution levels exceeding that of wild animal habitat are caused by vehicular sources, this have negative influence on behavior of wildlife in captivity. Study carried out for three seasons showed the daily variations in vehicular count and the related emissions for the Zoological gardens in Mysuru city. the average wind velocity for April, June and December was 2.12 m/s, 2.38 m/s and 1.95m/s, the Average concentration of Carbon monoxide and particulate matter at monitoring station was observed to be highest during summer 17.22 mg/m^3 and 712.2µg/m^3 with pollutant concentration exceeding National Ambient Air Quality Standards by 4.3 and 7.42 times. Carbon monoxide was the major pollutant found in terms of volume followed by Particulate matter, Nitrogen dioxide and Sulphur dioxide in Sequential order.
Keywords - Sensitive Area, Ambient Air Quality, Traffic flow.

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I. INTRODUCTION

In many Indian cities air quality is one of the intimidating issues to be concerned[1]–[3]. Outdoor air pollution is a major environmental concern causing health problems affecting both human and animals. Currently, in India, there is a high influx of population to urban areas, which has led to growing cities, sharp increase in traffic, trajectory growth, rapid economic development and industrialization, and higher levels of energy consumption. This unplanned urban and industrial development has led to the problem of air pollution[4]. Ambient air pollution in both urban and rural areas is estimated to cause 4.2 million premature deaths worldwide per year. This mortality is due to exposure to small particulate matter of 2.5 microns or less in diameter ($PM_{2.5}$), emitted predominantly because of burning vehicular fuel, which cause cardiovascular and respiratory disease, and cancers. Most sources of outdoor air pollution are well beyond the control of individuals and demands concerted action by local, national and regional level policy-makers working in sectors like transport, energy, waste management, urban planning, and agriculture [5]. Traffic congestion increases vehicle emissions and degrades ambient air quality and recent studies have shown excess morbidity and mortality for drivers, commuters and individuals living near major roadways[6]. Air quality crisis in cities is mainly due to vehicular emissions. Transportation systems are increasing everywhere and the improvements in technology are insufficient to counteract growth[7]. Road traffic induces air and noise pollution in urban environments having negative impacts on human health[8]. Near-road traffic-related air pollution is one of the most serious public health concerns facing many countries due to emissions of several toxic ambient air pollutants from on-road vehicles[9]

According to 2011 census, Mysore was the largest non-metropolitan city in India with population close to 10 million, had the highest basic infrastructure index of 2.846. Mysore is also a major tourist destination in its own right and serves as a base for other tourist attractions in the vicinity. Mysuru Zoo (officially the Sri Chamarajendra Zoological Gardens) is one of the city's most popular attractions, spread across sprawling 157-acre (64 ha) established in the year1892. It is one of the oldest and most popular zoos in India, and is home to a wide range of species. Wildlife is also vulnerable to harm from air pollution. Pollutant issues of concern include acid rain, heavy metals, persistent organic pollutants (POPs) and other toxic substances. Insects, worms, clams, fish, birds and mammals, all interact with their environment in different ways. As a result, each animal's exposure and vulnerability to the impacts of air pollution can be equally different. Air pollution can harm the quality of the environment or habitat in which they live. Air pollution has adversely affected animals since the

advent of the industrial revolution[10].Carnivores (>40 kg) which are large in size such as tiger, leopard and wolves are more susceptible to human disturbance like road building, settlements, farmlands, logging, poaching, grazing and quarrying and changes in the configuration and connectivity of habitats such as habitat fragmentation and loss [11], [12]

The aspiration of this study is to understand the effects of ambient air quality in sensitive area and to indicate the levels of air quality necessary with an adequate margin of safety to protect the health of different animal species living in make-believe habitat of urban area, to assist in establishing priorities for abatement and control of pollutant level.

II. METHODOLOGY

A. Study area

The Jayachamarajendra Zoological Garden situated at 12.3022° N, 76.6642° E spread across 157 acres. It is one of the oldest and most famous Zoo in India providing a natural habitat for the animals such as large to small cats, aquatics, birds, Primates and reptiles which include 168 species. Zoological garden houses currently 585 mammals, 736 birds, 105 reptiles, Karanji Lake is located adjacent to the zoo and Chamundi Hill is towards the South. The roads for the above locations are connected and situated in front of the zoological garden, also, National Highway is passing adjacent to zoological garden, and air pollutant loads were assessed around this sensitive location are shown in Fig 1 and 2.

B. Vehicular count

Traffic flow patterns and their time dependent variations were studied in a real-time frame-by-frame basis. This was achieved by using CCTV footages installed at the identified monitoring location. This technique eliminates the errors from direct manual observations. Here, the total number of vehicles and their categories for daily and weekly and evaluation of data.

***Fig. 1** Zoological garden and the surrounding major traffic routes*

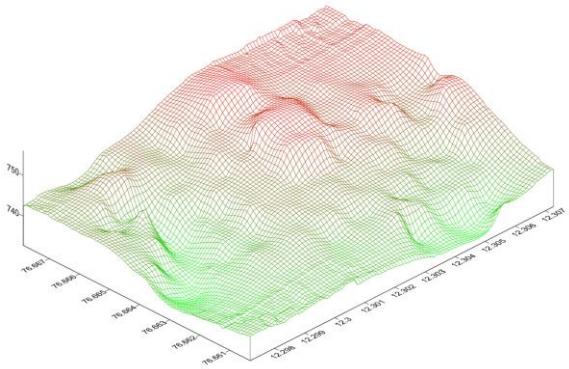

***Fig. 2** Digital elevation map of Sri Chamarajendra zoological garden*

III. RESULTS AND DISCUSSIONS

A. Traffic volume studies

The traffic flow at Chamarajendra Zoological Garden junction in Mysuru city was studied for 3 major seasons such as summer, monsoon and winter. Maximum 24hour vehicular count for three seasons recorded in the range 64787 being maximum count and 59812 being minimum count. The average of categorized contribution to the total traffic volume during summer season was 0.967% (trucks), 4.771% (buses), 5.864% (SUVs), 17.870% (cars), 16.078% (rickshaws) and 54.450% (2–wheelers). Average of categorized contribution to the total traffic volume during monsoon was 0.855% (trucks), 4.315% (buses), 5.908% (SUVs), 18.583% (cars), 16.454% (rickshaws) and 53.885% (2–wheelers). Average of categorized contribution to the total traffic volume during winter was 0.943% (trucks), 4.750% (buses), 5.916% (SUVs), 18.216% (cars), 16.296% (rickshaws) and 53.879% (2–wheelers).

B. Ambient air temperature and wind velocity

Ambient air temperature for the study area recorded at IMD station for three months namely April, June and December at every minute across 90 days for three seasons. **Summer** – The monthly average temperature recorded for April was 27.77 °C with maximum and minimum daily averages of 28.95 °C and 25.66 °C. the average wind speed for April was 2.12 m/s. **Monsoon** – The average temperature for June was 24.75 °C with maximum and minimum daily averages of 26.65 °C and 22.73 °. The average wind speed for June was 2.38 m/s. W**inter** – The average temperature for the month of December was 22.19 °C with maximum and minimum daily averages of 23.78 °C and 20.11 °. The average wind speed for the month of December was 1.95 m/s.

C. Windrose plots

A wind rose is a graphical representation which gives a succinct view of distribution of wind speed and direction of a particular location. Monthly variations in wind patterns were depicted by windrose diagrams for the study period by using WRPLOT software. Wind data were collected over a period of one year. Windrose plots for summer (April) and monsoon (June) and winter (December) seasons are shown in Fig. 3.2

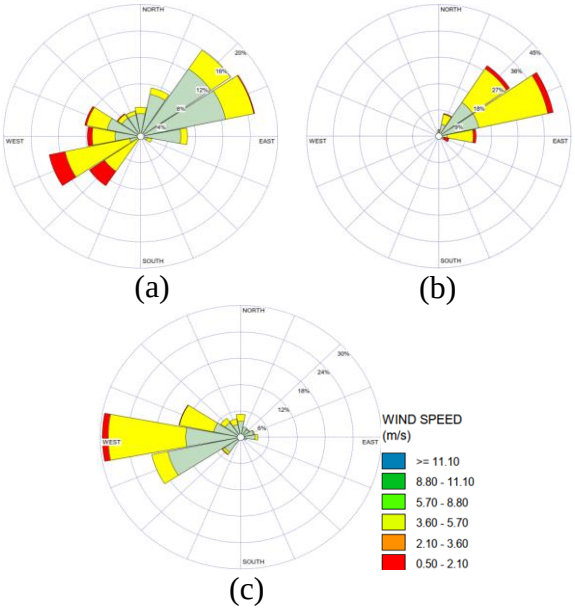

***Fig. 3** Windrose plots (a) Summer (b) Monsoon and (c) Winter for Mysuru*

D. Monitored ambient air quality

Chamarajendra Zoological Garden situated next to a major traffic junction connecting the Karanji Lake in the north and Chamundi Hill towards the South. The roads for the above locations are connected and situated as the periphery of zoological garden, carrying traffic loads in excess of 64,000 vehicles per day. The monitoring station located at the intersection of two perpendicular roads appraises the ambient air quality of Zoo; also indicate the impact of vehicular emissions. The ambient air quality for three seasons at this location is described and presented in Fig. 3

Summer - In the month of April, the air quality was monitored at station across the week for 5, 6, 7, 8, 9, 17th and 18th day. The total vehicular load during these days ranged from 59812-64787 per day. The wind direction during the monitoring period in this season was predominantly between S and SE (145.90° – 184.52°) at an intensity ranging from 1.37 – 2.67 m/s in direction of air quality monitoring stations.

CO –The concentration of CO was observed at the monitoring station ranging from 5.12 – 17.22 mg/m^3. The highest concentration at the station located near to road was 17.22 mg/m^3 on 5th day with wind speed of 2.10 m/s. Least concentration at this station was 5.12 mg/m^3 (70.26% lower than maximum concentration) on 1st day with a wind velocity of 2.25 m/s.

NO_2 –The concentration of NO_2 was observed to be the highest on the receptor near road ranging from 32.5 – 121µg/m^3. The highest concentration at the monitoring station located near to road was 121µg/m^3 on 05th day. Least concentration at this station was 32.5 µg/m^3 (72.91% lower than maximum concentration) on 08th day.

PM –The concentration of PM was observed to be the 2nd highest on the monitoring station ranging from 212.1– 742.2 µg/m^3. The highest concentration at the station located near to road was 742.2µg/m^3 on 5th day. Least concentration at this station was 212.1 µg/m^3 (71.42% lower than maximum concentration) on 1st day.

SO_2 – The concentration of SO_2 was observed to be the least among the monitored pollutants ranging from 19.2 – 68.4µg/m^3. The highest concentration at the station located near to road was 0.684µg/m^3 on 5th day. Least concentration at this station was 19.2 µg/m^3 (71.92% lower than maximum concentration) on 1st day.

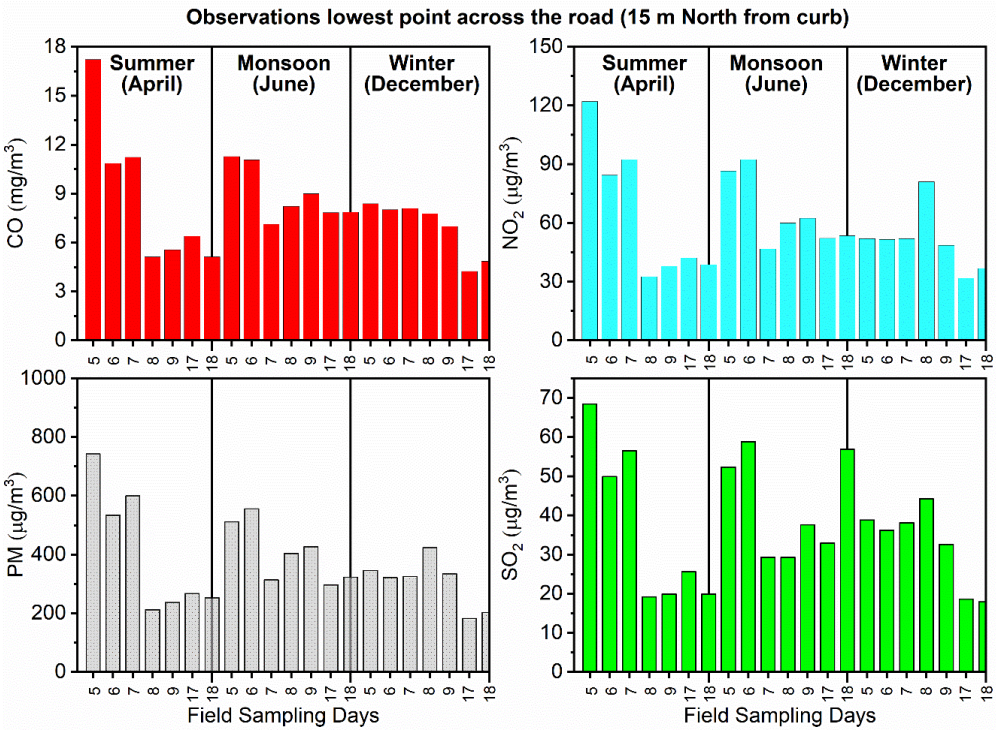

Fig. 4 Seasonal ambient air quality at Chamarajendra Zoological Garden

Monsoon –In the month of June, the air quality was monitored at roadside monitoring station across the week for 5, 6, 7, 8, 9, 17thand 18thday covering all days of the week. The total vehicular load during these days ranged from 54740-58730 per day. The wind direction during the monitoring period in this season was predominantly between SSW and WSW (201.13° – 263.37°) at an intensity ranging from 1.72 – 3.36 m/s resulting in movement of air pollutants from the road in front zoo to traverse the monitoring station.

CO – The concentration of CO was the highest on the monitoring station ranging from 7.86 – 11.28 mg/m^3. The highest concentration at the station located near to road was 11.28mg/m^3 on 5th day with wind speed of 2.02 m/s. Least concentration at this station was 7.86mg/m^3 (30.31% lower than maximum concentration) on 7th day with wind velocity of 1.70 m/s.

NO_2– The concentration of NO_2 was on the station ranged from 52.2- 92.3 µg/m^3. The highest concentration at the station located near to road was 92.3 µg/m^3 on 6th day. Least concentration at this station was 52.2 µg/m^3 (43.44% lower than maximum concentration) on 7th day.

PM – The concentration of PM was on the monitoring station ranging from 29.65 – 55.20µg/m^3. The highest concentration at the station of 55.20µg/m^3 was on 6th day. Least concentration at this station was 50 µg/m^3 (46.28% lower than maximum concentration) on 17th day.

SO_2 – The concentration of SO_2 was observed to be the least among the monitored pollutants ranging from 29.3 – 58.3 µg/m^3. The highest concentration at the station located near to road was 58.3 µg/m^3 on 6th day. Least concentration at this station was 29.3µg/m^3 (49.74% lower than maximum concentration) on 8th day.

Winter – In the month of December, the air quality was monitored at station across the week for 5, 6, 7, 8, 9, 17th and 18th day covering all days of the week. The total vehicular load during these days ranged from 55911-61486 per day. The wind direction during the monitoring period fluctuated between ENE and S (76.56° – 185.12°) at an intensity ranging from 1.37 – 2.67 m/s resulting in movement of air pollutants from the road at the West (Right side) of the zoo to traverse the monitoring station.

CO – The concentration of CO was observed to be the highest on the monitoring station ranging from 4.23 – 8.38 mg/m^3. The highest concentration at the station located near to road was 8.38 mg/m^3 on 5th day with highest wind speed of 2.10 m/s. Least concentration at this station was 4.23 mg/m^3 (49.52% lower than maximum concentration) on 17th day with least wind velocity of 2.07 m/s.

NO_2 – The concentration of NO_2 at the monitoring station ranged from 31.8 – 81µg/m^3. The highest concentration at the station located near to road was 81 µg/m^3 on 8th day. Least concentration at this station was 31.8 µg/m^3 (60.25% lower than maximum concentration) on 17th day.

PM– The concentration of PM at the monitoring station ranged from 182.2 – 423.6 $\mu g/m^3$. The maximum concentration of 423.6 $\mu g/m^3$ at the station located near to road was on 08^{th} day. Least concentration at this station was 182.2 $\mu g/m^3$ (56.98% lower than maximum concentration) on 17^{th} day.

SO_2– The concentration of SO_2 was observed to be the least among the monitored pollutants ranging from 17.9 – 42.2 $\mu g/m^3$. The highest concentration at the station located near to road was 42.2 $\mu g/m^3$ on 8^{th} day. Least concentration at this station was 17.9 $\mu g/m^3$ (57.58% lower than maximum concentration) on 18^{th} day.

The observed concentrations of CO were twice higher than the standards and PM was up to 4 times higher during winter season due to low temperature and wind directions carrying pollutants towards the monitoring station. However, NO_2 and SO_2 concentrations were well below the NAAQS.

It may be summarized that the average ambient air quality near Jayachamarajendra Zoological Garden was observed to be highest during summer for with pollutant concentration critically exceeded NAAQS for PM up to 2.12 - 7.42 times followed by winter (1.82 – 4.23) and for monsoon it was well below NAAQS. Similarly, the concentrations of CO were highest during summer ranging from 1.28 – 4.3 times the NAAQS followed by winter (1.96 – 2.82) and winter (1.05 – 2.09). NO_2 and SO_2 levels were well below the standard limit for all seasons. The pollutant concentrations at road adjacent to Zoo was high for all seasons due to the high traffic load and lower elevation at which the monitoring station was located.

IV. CONCLUSIONS

The framework used in this study to understand the impact of vehicular traffic on sensitive location can be adopted easily not only to examine similar effects on mocked ecosystem but also in natural ecosystem through which major highways are passing through and also to understand the impact of vehicular pollution on other such sensitive locations of urban and semi urban area. Traffic flow on the periphery road surrounding zoological garden seems to have negative impacts on the ambient air quality of the garden. Ambient air quality monitoring around Sri Chamarajendra zoological garden sensitive location for three major seasons carried out indicated the pollutant concentrations in outdoor environment. Wind direction and speed had played important role in scavenging the pollutants from the road to sensitive location. It is found that the average ambient air quality near Jayachamarajendra Zoological Garden was observed to be highest during summer for with pollutant concentration critically exceeded NAAQS for the pollutant concentrations in monsoon remained similar to that of summer and ~30% lower for winter. Comparatively the pollutant concentrations were high for all seasons due to the high traffic load and lower elevation at which the monitoring station was located. The wind from southwest have greater effects in spring, due to the influence of winds passing from SW through highways. More specifically, winds blowing in the southwest direction have the largest year-round impacts on ambient air pollution levels of Zoological gardens. carbon monoxide was the major pollutant found in terms of volume followed by Particulate matter, Nitrogen dioxide and Sulphur dioxide in Sequential order. Ambient air quality concentration of CO, NO_2, PM and SO_2 observed at sensitive location is far exceeding over the national ambient air quality standards. Although, due to the lack of-specific studies, quantifications of health impacts are uncertain, the high exposure to air pollution imposes serious burdens on the health of the sensitive animal population.

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