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Quantification of Air Pollutants – A Case Study of Sangli Bus Stand

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***Abstract :-* Sangli city bus stand is a public transport facility intended to commence or terminate local and long journey through Maharashtra State Transport Corporation. It is one of the most crowded bus stands to meet public transportation facilities. Also it is a micro region where number of buses commences, terminate, park, idle as well as accelerate and decelerate. To meet running population demand and to achieve smooth public transport facility it is required to increase number and frequency of transit buses. It results in increase in concentration of pollutants, as most of the buses are propelled by heavy-duty diesel engines which are the major contributors to vehicular pollution. The bus stand is located in heart of city and mostly bounded from all sides except entry and exit way of buses. This causes accumulation of heavy concentration of pollutants emitted by heavy duty-diesel buses and is a major site for common people to suffer from polluted air related health hazards similar to other urban cities. As such automobile induced air pollution at city bus stands is a crucial issue and needs to be attended at earliest. The purpose of this study was to attempt for suitable methodology for quantification of bus emissions generated at Sangli bus stand. This paper reviews number of studies based on transit bus emissions generated at bus stand and also discusses the method adopted for quantification of air pollutants at Sangli city bus stand. The studies conducted at abroad have demonstrated pollution potential of buses. Various researches have suggested change in design layouts and use of alternative fuels to establish the control.**

***Keywords:* - Automobile pollution, Hydrocarbons.**

I. INTRODUCTION

As the population is increasing day by day, there is need to fulfil public demand like transportation facility. Therefore, resulting in more number of vehicles including public and private transport vehicles. Public transport (also known as public transit, or mass transit) is a shared passenger transport service which is available for use by the general public, as distinct from modes such as hired buses, taxicab or carpooling. These places are mostly very crowded to meet increasing transport facility (Litman 7, 2017).

Public spaces such as bus stands are microenvironments associated with intense and highly localized emissions from automobiles. These are the spaces used for climbing up or down for the passengers. The stop-start driving behaviour has been shown to lead to higher emissions not only from engines but also from ground surfaces (Buonanno 2 et al., 2011.) In consequence, a few minutes wait at bus stand for a bus may represent a period of disproportionately high exposure to emitted pollutants (Moore12 et al., 2011). The main pollutants emitted from heavy-duty diesel-powered buses are hydrocarbons, lead/benzene, carbon monoxide, sulphur dioxide, nitrogen dioxide and particulate matter (Watson15 et al., 1988). These pollutants are major precursor for cough, headache, nausea, irritation of eyes, various bronchial and visibility problems. The automobile induced pollution in bus stand areas, particularly in big cities, seems to be a serious problem (Mathew 10, 2014).

In Indian context, most of the bus stands have been located in the heart of the cities and are handling very high frequency of buses to meet with ever growing demand of exploded population. As the number and frequency of buses are increasing day by day within a fixes and bounded area, the concentration of the air pollutants is also increasing which tends to impact on living as well as on non-living things. It can be seen that most of the studies have been focused only on emissions from automobile engines, various category of vehicles and its impact along with seasonal variation and the study on emission of buses along the journey route. A few studies have been conducted in abroad. But there is no data pertaining the air pollution and its impact due to number and frequency of buses in microenvironments of bus stands for Indian cities.

Thus, there is need of a study to establish a relationship between frequency of bus operation and area of bus stand handling the frequency of buses in air pollution point of view. The composition of air pollutants and its quality within bus stand area is never uniform. It changes over carriage capacity of the bus stand, its region, topography, season and also societal trends of that region. In India, utilization of bus facility for routine transportation has increased significantly in age old designed, restricted and crowded bus stands of the cities. Most of the buses are propelled by heavy-duty diesel engine, emitting harmful air pollutants. The emissions over the limited bounds lead to negative effect on air quality and public health. There are few studies about bus emissions at bus stands, review of which is taken as follows.

Bus shelters are also microenvironments where commuter's exposure to fine particulate matter take place during pre- journey. For this purpose, Hess et al., (2010) studied seven bus shelters in Buffalo, New York. Site selection is based on minimum variability in environmental factors and bus shelter. The DustTrak Aerosol Monitor 8534 Model is used for removal of particles less than 2.5µm in size. It is found that the mean value of PM2.5 inside bus shelters (17.24 mg m-3) is higher than the mean value outside bus shelters (14.72 mg m-3) and the mean PM2.5 in the morning (18.84 mg m-3) is higher than the afternoon mean (13.08 mg m-3). Ordinary Least Square (OLS) regression model is used to model the relationship between exposure to PM2.5 and various characteristics of a bus shelter, environmental factors, time and location. Model results suggest that exposure to PM2.5 inside a bus shelter is 18 % higher than exposure outside a bus shelter. So focus should be to inform transit agencies on preferred shelter configurations and placements.

Crowded junctions are also microenvironments where maximum number of vehicles passes. It is almost bounded regions by residential and commercial buildings which results in high concentration of pollution. At this place drivers decelerate, idle and accelerate according to traffic signal, which results in high vehicular emission. Based on this concept study was undertaken for Sangli city by Tejswini Mali (2013). The study was focused to know air pollution potential of vehicles on ambient air quality at Sangli city. Firstly, most crowded junctions in the city were identified. At selected junctions, vehicle emission patterns of PM, SO2, CO and NOx was monitored. Air quality monitoring was done by High Volume Sampler (HVS) and handy air samplers. Based on number of vehicles passing at selected junction and ambient air concentration of pollutants, pollution patterns were established. For each vehicle category emission factor was assigned to calculate emission load at each junction. Result shows that the NOx emissions are higher at all the junctions (11000 gm/km). Annual average and maximum 24 hour average of the selected pollutants. The author suggested application of suitable remedial measures to lower pollutant level at selected junctions and hence ambient quality.

Yu et al., (2013) - the purpose of this research is to demonstrate a methodology for quantification of bus emissions generated near bus stops based on the real-world on-road emissions data collected by the Portable Emission Measurement System (PEMS). Stop influence zone is defined as the area in which the normal bus driving is interrupted by bus stops. The second-by-second data were screened out within the stop influence zone. And the bus running state near a stop was classified into three driving modes, deceleration, idling, and acceleration. Then emission characteristics were analysed for each mode. Under the idling condition, the emission rates (g s-1) were not constant all the time. The NOX emission rate decreased in the first 4 to 6 second while the corresponding emission rates of CO2, CO, NOX, and HC increased in the last 4 second of idling. Besides, the influence of bus stop characteristics on emissions was investigated using statistical methods. Platform type, length and location of bus stops showed significant effects on the length of the stop influence zone. However, there were no significant effects on distance based emission factors.

Another study has taken place at Singapore by Velasco and Tan (2016). The study is focused on particles exposure while sitting at bus stands of hot and humid environment. Five representative and crowded bus stands with different characteristics is selected. DustTrak Aerosol Monitor 8534 Model is used to measure mass concentration of priority parameters PM10, PM2.5. Statistical study shows all pollutant parameters measured at different bus stands is highly variable. With the exception of bus stand (BS-5), other four bus stands shows all pollutant parameters above range due to its location in close proximity to traffic intersection where drivers decelerate, idle and accelerate, it is almost 100 µg/m3 and mean value is 34 µg/m3.Higher frequency during the peak of the rush hours (8am – 9.30am) and (6pm -7.30pm). Small change in meteorological conditions (ambient temp, RH) affect the pollution level. Waiting for a bus in a hot, humid, noisy and polluted environment discourages the use of public transport. A better design of the bus stands, investments in electric public transport will improve air quality.

The location of a bus stop not only concerns the quality and efficiency of transportation of buses

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within bus stand area, but also has a direct impact on urban environment. Therefore proper location of bus stand is also important in terms of environmental pollution. This kind of study is taken place at China by Li et al., (2016). The study is incorporated emission reduction in the site evaluation of urban bus stands near intersections. Use of microscopic traffic simulation model (VISSIM) and Motor Vehicle Emission Simulator (MOVES) is done. Using VISSIM, traffic simulation is done with varying distance between bus stand and intersection which gives traffic index. Simultaneously, emission simulation MOVES is run to calculate the average emission rate of CO2, CO, NOx, and HC (g/km) for uses and passenger cars. The Grey Relational Analysis (GRA) method is then employed to incorporate emissions reduction in the site evaluation of urban bus stop near intersections. Combining two advanced software, VISSIM and MOVES helps to simulate traffic operation and vehicle emission which improve the traffic efficiency and reduce the vehicle emissions. It provides a good guidance for the site selection of the bus stop near an intersection.

From above literature review, some studies focus on bus emission at bus shelter and along the route of the bus journey and its effect on living beings. Traffic simulation models can also be used to improve vehicle operation efficiency and hence to reduce vehicle emission. Some studies have focused on modelling and prediction of pollution level for similar site situation. On the basis of these studies a need was felt to quantify air pollutants in micro regions of bus stands in relation with number and frequency of buses.

II. MATERAL AND METHODS

Sangli city (16.87 N, 47.57 E) is a district place situated in Western Maharashtra. Sangli city population with a present/more than of 5 lac has almost double rise as compared to 2011 census is increasing with very high rate. Increase in population demands actual proportionate increase in public transport facility. Thus, central bus stand area is a very crowded place overloaded by passengers, buses and many other vehicles. The increase in users, number of buses over a restricted area their age as well as maintenance seems to be obvious reasons for environment degradation. However in past years a study was not undertaken to know the impact of pollutant emission at bus stand on air quality. This study is undertaken with the same objective. The site location for the proposed work is shown in Fig I

Fig I Sangli Bus Stand

For the given location, the data is collected, in terms of number and frequency of buses. The frequency of buses is considered as an event comprising as the combined activity (cycle) of arrival and departure of bus within a given time period.

e.g. Say 'x' bus travelling from Sangli to Ashta (22km from Sangli,) requires half an hour to reach and another half an hour to come back to Sangli bus stand. Consider this operation as one cycle i.e., frequency of 'x' bus is one. If the same operation considered for 2hr, then bus completes two cycles i.e., frequency of bus is two. With the same concept, the total frequency of all buses visiting to Sangli bus stand is counted. There is variation in frequency of buses throughout a day. As per the information collected from Sangli depot office, the frequency of buses on weekdays (Monday to Saturday) is almost same and it reduces on Sunday only. Therefore the collected data has been presented in graphical format to get clear idea of minimum, average and maximum frequency of buses on weekday and Sunday as shown in Fig II

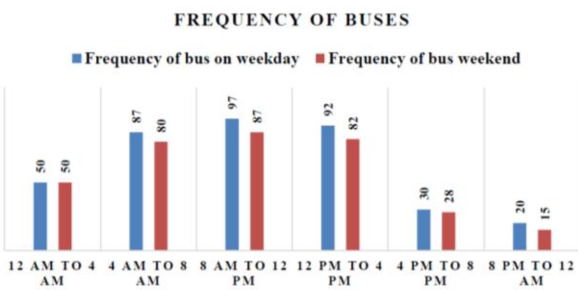

Fig II Frequency of Buses

From above fig, the frequency of buses is maximum from 8 AM to 4 PM on weekday as well on Sunday. The period of maximum frequency of buses is

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based on the maximum number of bus users i.e., the presence of bus users is maximum in that period - from 8 AM to 4 PM. Hence the relative count of the buses needs to be taken in the account to study impact of pollutants. The pollutant concentration were monitored using High Volume Sampler (HVS), CO Analyzer (SR - 90), HC Analyzer (SR - 2016).

For Ambient Air Monitoring, CPCB guidelines are referred. According to these guidelines, the number and location of monitoring station was determined. For better and reliable results the frequency of monitoring was also determined, as once in a 15 days. (CPCB MoEF: NAAQMS: 2011-12). The parameters PM, SO2, NOX, CO and HC were selected for the actual monitoring at selected sites. The monitoring is done on weekday as well as on Sunday, as the frequency is maximum and minimum respectively. The monitoring is done from January to March with the frequency of once in a 15 days over 24 hrs (6 am to 6 am).

III. RESULT AND DISCUSSION:

3.1 Estimated Emission at Sangli city

The emissions from buses are estimated to calculate the emission load at bus stand area and vicinity. Monitoring period is from January 2017 to March 2017. The average readings (Jan to Mar) are calculated to show variation in pollutant concentration. It is as shown in fig III

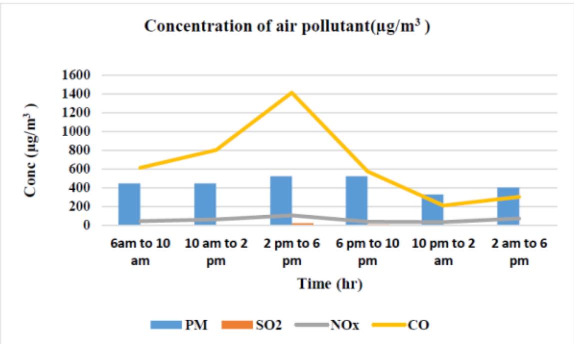

Fig III Concentration of air pollutants at city bus stand, Sangli

From above fig, there is variation in estimated concentrations of air pollutants with time. Maximum concentration of pollutants is in between 10 AM to 10 PM. From Fig III, the maximum number and frequency of buses is between 8 AM to 4 PM whereas maximum number of commuters travel, also depot staff is present and various bus operation takes place during this period. This results in commuters and staff members exposure to maximum pollutant concentration. This results in hazardous situation and uncomforting and uneasy atmosphere to spend time at bus stand by commuters and staff members.

Table I Pollutant concentration standards

Comparison with Standards (μg/m3)				
Pollutant	PM	SO_2	NO_2	CO
Time Weighted Avg	24 hr	24 hr	24 hr	1 hr
Conc in Ambient Air (μg/m3)	200	80	80	4000

From estimated air pollutants at city bus stand and the standards given by CPCB, comparison is given in following Table I. It illustrates that the Concentration of PM and NOx is higher than the given standards and the concentration of SOX, CO and HC (% CH4 in air by volume) are within given standards

3.2 Correlation between number and frequency of buses and pollutant concentration:

To establish a trend between number and frequency of buses and concentration of pollutant (i.e., PM, SOX, NOX, CO and HC) the correlation study was carried out. For this study, the bus number and its frequency is counted for continue 15 days and then the days belong to maximum and minimum number and frequency of buses is decided. The air samples were taken during these days for determination of concentrations for PM, SOX, NOX, CO and HC. The correlation coefficient was determined with help of Microsoft Excel tool.

Table II Correlation between pollutant parameters and bus number

vehicle	**PM**	**SOX**	**NOX**	**CO**
Bus	1	1	1	1

From calculated concentration of air pollutants at city bus stand and the standards given by CPCB, comparison is given in the following table II, it illustrates that the concentration of SPM and NOx is higher than the given standards and the concentration of SOx and CO are within given standards.

IV. CONCLUSIONS

This paper demonstrates a method to evaluate the emission of air pollutants caused due to frequent stop-start and acceleration and retardation of buses at Sangli bus stand. The emissions of diesel bus were studied with characteristics of buses and the general information of bus stand. The bus driving modes at bus stand are very different with those on road links. The pollutant emission at bus stand w.r.t. number and frequency of buses gives an idea about heavy concentration in limited area and hence results in commuters discomfort, as they are exposed to high concentrations in short time. Based on bus count, its frequency and actual emission patterns it can be concluded that there is a high concentration of SPM and NOx as compared to AAQS. Other pollutants CO, HC and SOx are within standard limits given by CPCB (2011). There is strong correlation in between number of buses and pollutant concentration. The findings are specific to the conditions of the case study, including the specific monitoring equipments used and the conditions under which it operated. There is a need of further study to know health impact on the permanent staff exposed continuously to the pollutants.

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