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AIR POLLUTION DISPERSION MODELING FOR DIESEL GENERATORS AT JAMIA UNIVERSITY CAMPUS, NEW DELHI, INDIA

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ABSTRACT: The study is conducted in order to assess the contribution of pollutants from the Diesel generators running in the Jamia Millia Islamia campus. In this work, ISCST3 air pollution model was applied to simulate the air quality for 24 hourly average ground level concentrations of SOx,NOx,PM and 8 hourly average for CO at various receptor locations. Based on surveys and questionnaires, an inventory was formulated for different Gensets and their characteristics. The ISCST3 model is based on a steady-state Gaussian plume algorithm. It has been developed by USEPA for assessing air quality impact from point, area, and volume sources. Emission rates for Different pollutants have been computed using empirical formulas for Gensets based on their capacity. Pollutant emitting potential has also been computed in this study. The predicted values simulated by ISCST3 model are 11.33μg/m^3 for PM10,58.43 μg/m^3 for SOx, 176.50 μg/m^3 for NOx, and 57.02 μg/m^3 for CO. Both monitored and predicted values have been compared with NAAQS 2009. A pragmatic solution for curtailing the pollution load in the area has been proposed in the research which will further assist in managing the air quality scenario for the region. . Both monitored and simulated values have been compared with NAAQS 2009. A possible solution for minimizing the pollutant load in the area via Diesel Gensets has been suggested in this research which will further help in managing the air quality scenario the Study area

Keywords: ISCST3, Emission rate, Emission modeling

I. INTRODUCTION

With the advent of rapid urbanization and rising air pollution load, It has become quite essential to curb the air pollution exposure by precisely assessing the air quality [6] [13]. The problem of Air pollution in Delhi has been in the spotlight for over a decade and it has now been recognized as a brainstorming issue for the whole nation [7] [14]. Over the last two decades petrol and diesel consumption have grown by 400% and 300% respectively which has led to the rise of vehicular pollution as well as pollution due to other sources like DG sets, Industries, waste incinerators[8] [15] [16]. A typical diesel generator exhaust includes more than 40 toxic air contaminants including a variety of carcinogenic compounds like Benzene, Arsenic, Formaldehyde and Oxides of Nitrogen [9]. Emissions from diesel generators in the form of NOx, CO and Hydrocarbons chiefly contribute to the deteriorating air quality in the capital [10]. Many air quality models have been used throughout the world for air pollution dispersion that enables effective evaluation of the impacts of air pollution on urban air quality. In 2003 Gooi et al. simulated the air pollution levels using ISCST3EM model caused by inner city traffic in Malaysia, and had compared the emissions with the available national and international standards, based on their analysis they were able to assess the potential health hazards caused by the air pollution so generated [11]. A comprehensive modeling study of PM10 in Treasure valley,Idaho(2011) was executed by Darko et al.. Their study utilized the services of ISCST3 model where the simulated values were found in agreement with measurements in both temporal and patterns and annual averages [12].

II. METHODOLOGY

The main aim of this study is to model the air quality in Jamia University Campus, New Delhi, India by ISCST3 air quality modeling tool. The elevated levels of pollutant concentration due to Diesel based generators and their effects on the surrounding air quality have been studied in this research. Our study has been executed in three stages, the first stage involves assimilation of generator data i.e. generator capacity, characteristics, location, fuel consumption, unit installation. Once the data was formulated then the next stage was executed where the pollutants emission rate for NOx ,SO_2,CO were computed so to be further utilized in ISCST3 model. In the next stage the pollutant potential of generator based on its capacity was determined and also the emission rate for each pollutant was computed. The final stage involves inputting all the required parameters for model run and comparison of simulated data with NAAQS.

A. AREA OF STUDY

Jamia University being located on the south-east corner of Delhi is well connected to all key parts of the city. The university campus covers an area of almost 216 acres with a thick amount of green cover in the entire campus. The DMS latitude of the university is 28° 33' 41.9652" N and DMS longitude is 77° 16' 52.5288" E, lying in the UTM zone 43R the campus has an elevation of 215m. Based on number of source apportionment studies done it has been observed that diesel based generators contribute heavily in the deteriorating air quality of the campus. A total of 40 generators of varying capacity have been installed at pertinent locations having a total capacity of 8650.5 KVA.

Fig.1. Generator location in the campus

B. DATA COLLECTION OF DIESEL GENERATORS

Following list is showing fuel consumption @ 75% load (liters/hour) and actual installation place of 10 numbers of generators out of 40 along with their Geographical locations.

Sr. No	KVA	No.	Fuel consum-ption @ 75% load (lt/hr)*	Place of Installation	Co-ordinates x, y (m)	
					x	Y
	-	-	-	Main gate of F/O Engg.	0	0
1	125	01	20	Registrar Office	600	-70
2	140	01	22	Jamana L Bajaj House Admin	636	-77
3	125	01	20	Middle School	460	266
4	250	01	42.6	Ansari Auditorium	518	-55
5	200	01	34.4	Main Building MCRC	620	-80
6	150	01	25	Studio Main Building MCRC	620	-80
7	63	01	11.5	Old Studio Building MCRC	620	-80
8	160	01	27.7	Bio-Science Building	620	-80
9	100	01	16.9	Department of Chemistry	620	-80
10	50	01	8.0	Examination Branch	650	-70

Table 1-10 generator locations

In total there are around 40 diesel Generators sets installed in different departments of the University varying from 15KVA to 1250 KVA. Fuel consumption data is based on diesel having specific Gravity of 0.85 and conforming to IS: 1460:2005. In this study we have considered generator operation time only 1 hr. in a day and 300 hrs in a year for the pollutants emission calculations. Total consumption of all Gensets is 1432.2 lt/hr(378.38 gal/hr).

III. AIR QUALITY MODELING

Ambient concentration levels of PM10, SOx and NOx have been predicted in winter season using the Industrial Source Complex Short Term (ISCST3) model. The ISCST3 model is based on a steady-state Gaussian plume algorithm, and is applicable for estimating ambient impacts from point, area, and volume sources out to a distance of about 50 kilometers.

A. Modeling Requisite

Characteristics of different Gensets :

Installed generator characteristics have been shown under which includes, stack height, exit temperature of flue gas, exit velocity and exhaust diameter of generator. Out of 40 generators only 10 have been represented in the table.

Table 2- Genset data required for model run [3] [4]

Genset No.	KVA	Stack Height (HS), m	Exit Temp. (Ts) (K)	Exit Velocity (Vs), m/s	Exhaust Dia (Ds), mm
1	125	22	600	6	115
2	140	22	600	8	165
3	125	22	600	6	115
4	250	25	700	10	200
5	200	25	650	10	180
6	150	22	600	8	165
7	63	20	550	5	90
8	160	22	650	8	165
9	100	20	550	6	115
10	50	20	550	5	90

Fuel consumption and emission rates for different Gensets :

The Emission rate calculation has been shown below:

$$\textit{Emission rate for SOx in g/s}$$

$$= \frac{\textit{Fuel consumption rate x Density of diesel x1000grams}}{1800}$$

$$\textit{Emission rate for NOx in g/s}$$

$$= \frac{3.85 \; x \; \textit{Dieselgenerator capacity in Hp}}{3600}$$

$$\textit{Emission rate for PM10 in g/s}$$

$$= \frac{0.24 \; x \; \textit{Dieselgenerator capacity in Hp}}{3600}$$

$$\textit{Emission rate for CO in g/s}$$

$$= \frac{0.045 \; x \; \textit{Dieselgenerator capacity in Hp}}{3600}$$

[1][2][5]

Table 3 - Fuel consumption and emission rates of 10 Gensets [1] [2]

S. No.	Rating (hp)	Fuel intake (l/hr)	Sox Emiss. Rate Qs (g/sec)	NOx Emiss. Rate Qs (g/sec)	PM10 Emiss. Rate Qs (g/sec)	CO Emiss. Rate Qs (g/sec)
1	142.38	20	0.047	0.152	0.009	0.045
2	159.46	22	0.052	0.171	0.011	0.051
3	142.38	20	0.047	0.152	0.009	0.045
4	284.75	42.6	0.101	0.289	0.015	0.078
5	227.80	34.4	0.081	0.231	0.015	0.062
6	170.85	25	0.059	0.183	0.011	0.055
7	71.76	11.5	0.027	0.079	0.008	0.044
8	182.24	27.7	0.065	0.185	0.010	0.050
9	113.90	16.9	0.040	0.122	0.008	0.036
10	56.95	8	0.019	0.063	0.006	0.035

IV. MODEL RUN

Data required for model run for predicting is:

(i) Source data: physical dimensions (stack location, stack height, stack top inner diameter), as well as exit velocity and temperature of gas and pollutant emission rate,

(ii) Hourly meteorological data for the simulation period: wind speed, wind direction, ambient temperature, stability class and mixing height and

(iii) Receptor data: receptor coordinates and height of receptor

The Prediction result for CO by ISCST3 model after inputting all the required parameters has been shown in figure 1 below

```
**             SRCID     QS        HS      TS       VS      DS
**             -----     -----     -----   -----    -----   ----
SO SRCPARAM    GENSET1   0.045     22      600.0    06.0    0.115
SO SRCPARAM    GENSET2   0.051     22      600.0    08.0    0.165
SO SRCPARAM    GENSET3   0.045     22      600.0    06.0    0.115
SO SRCPARAM    GENSET4   0.078     25      700.0    10.0    0.200
SO SRCPARAM    GENSET5   0.062     25      650.0    10.0    0.180
SO SRCPARAM    GENSET6   0.055     22      600.0    08.0    0.165
SO SRCPARAM    GENSET7   0.044     20      550.0    05.0    0.090
SO SRCPARAM    GENSET8   0.050     22      650.0    08.0    0.165
SO SRCPARAM    GENSET9   0.036     20      550.0    06.0    0.115
SO SRCPARAM    GENSET10  0.035     20      550.0    05.0    0.090
SO SRCPARAM    GENSET11  0.051     22      600.0    08.0    0.165
SO SRCPARAM    GENSET12  0.131     26      900.0    15.0    0.200
SO SRCPARAM    GENSET13  0.051     22      600.0    08.0    0.165
SO SRCPARAM    GENSET14  0.078     25      700.0    10.0    0.200
SO SRCPARAM    GENSET15  0.045     22      600.0    06.0    0.115
SO SRCPARAM    GENSET16  0.051     22      600.0    08.0    0.165
SO SRCPARAM    GENSET17  0.045     22      600.0    06.0    0.115
SO SRCPARAM    GENSET18  0.043     20      550.0    05.0    0.090
SO SRCPARAM    GENSET19  0.050     22      650.0    08.0    0.165
SO SRCPARAM    GENSET20  0.062     25      650.0    10.0    0.180
SO SRCPARAM    GENSET21  0.051     22      600.0    08.0    0.165
SO SRCPARAM    GENSET22  0.045     22      600.0    06.0    0.115
SO SRCPARAM    GENSET23  0.045     22      600.0    06.0    0.115
SO SRCPARAM    GENSET24  0.078     25      700.0    10.0    0.200
SO SRCPARAM    GENSET25  0.301     35      1020.0   45.0    0.300
SO SRCPARAM    GENSET26  0.078     25      700.0    10.0    0.200
SO SRCPARAM    GENSET27  0.045     22      600.0    06.0    0.115
SO SRCPARAM    GENSET28  0.172     28      900.0    19.0    0.200
SO SRCPARAM    GENSET29  0.172     29      900.0    19.0    0.200
SO SRCPARAM    GENSET30  0.180     30      1000.0   40.0    0.250
SO SRCPARAM    GENSET31  0.172     28      900.0    19.0    0.200
SO SRCPARAM    GENSET32  0.078     25      700.0    10.0    0.200
SO SRCPARAM    GENSET33  0.036     22      600.0    06.0    0.115
SO SRCPARAM    GENSET34  0.021     20      550.0    03.0    0.075
SO SRCPARAM    GENSET35  0.010     20      550.0    03.0    0.075
SO SRCPARAM    GENSET36  0.180     30      1000.0   40.0    0.250
SO SRCPARAM    GENSET37  0.180     30      1000.0   40.0    0.250
SO SRCPARAM    GENSET38  0.078     25      700.0    10.0    0.200
SO SRCPARAM    GENSET39  0.051     22      600.0    08.0    0.165
SO SRCPARAM    GENSET40  0.010     20      550.0    03.0    0.075

SO EMISUNIT     1.0E+06 GRAMS/SEC    MICROGRAMS/M**3
```

Fig. 2. ISCST3 model run for CO

V. RESULT

The ground level pollutants concentrations of PM10, SOx, NOx & CO for this study were predicted through ISCST3 model. The maximum values of average predicted PM10, SOx, NOx and CO concentrations have been shown in table 4 below.

Table4-Predicted and monitored values in comparison to NAAQS

S. no.	Air quality parameters	Time weighted average	Max predicted values, (µg/m^3)	Monitored values (µg/m^3)	NAAQS, (µg/m^3)
1	**PM10**	**24 hr**	**11.33**	**392**	**100**
2	**SOx**	**24 hr**	**58.40**	**18.7**	**80**
3	**NOx**	**24 hr**	**176.50**	**57.8**	**80**
4	**CO**	**8 hr**	**57.02**	**1140**	**2000**

The maximum value for PM10 concentration has been observed as 11.33 µg/m^3 at the receptor location (800.00, 0.00, and 0.00). In fact, the predicted PM10 value when compared with the standard value of 24 hourly PM10 concentration prescribed by the CPCB was found to be much lower. The predicted ground level SOx concentration of 58.37 µg/m^3 was observed which was found to be within the CPCB standard/limits of 80 µg/m^3. Finally the predicted maximum value of 176.49 µg/m^3 was simulated for NOx and the value exceeded the CPCB standard/limits of 80 µg/m^3 for the residential area. The comparison between observed and simulated data has been shown in figure below.

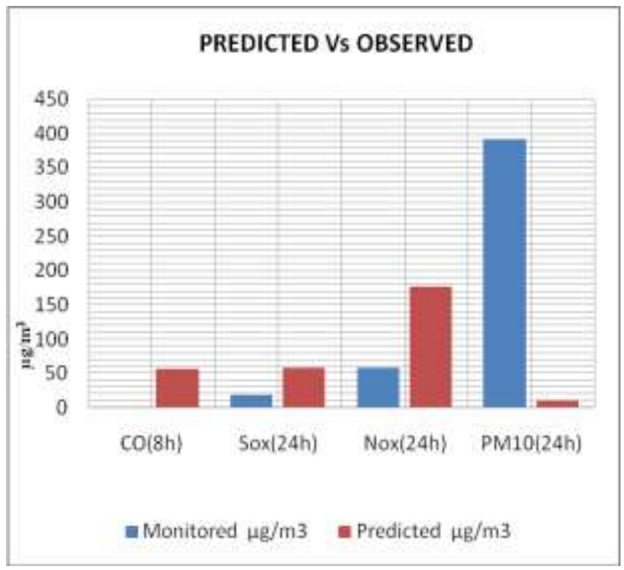

Fig.3. Comparison of predicted and observed data

VI. CONCLUSION

ISCST3 and local meteorological data were used to predict the concentration of major air pollutants in the campus area. Our findings indicate that after the implementation of the proposed project, concentrations of air pollutant are found to be well below the permissible CPCB Standards for ambient air quality. However, the PM concentration is elevated due to the Construction, traffic and diesel generators implementing proper Environmental Management Plan along with mitigation measures like Water sprinklers, and trees planting, around the industrial area can minimize the pollution and protect the environment from the adverse effects.

VII. RECOMMENDATIONS

We can install 4 Gensets having capacity 2500 kVA, instead of 40 Gensets of 8650 kVA capacity, the pollutants concentration will be reduced nearly half of their previous concentration value for PM_{10}, SOx & CO.

Table5 - Comparison between 40 Gensets Conc. & recommended 4 Gensets Concentration

S. No.	Air quality parameters	Time weighted average	Conc. from 40 Gensets (8650kva), µg/m3	Conc. from 4 Genset(2500 kvaX4), $\mu g/m^3$
1	**PM10**	**24 hr**	**11.33**	**4.41**
2	**SOx**	**24 hr**	**58.4**	**26.47**
3	**NOx**	**24 hr**	**176.5**	**166.56**
4	**CO**	**8 hr**	**57.02**	**16.2**

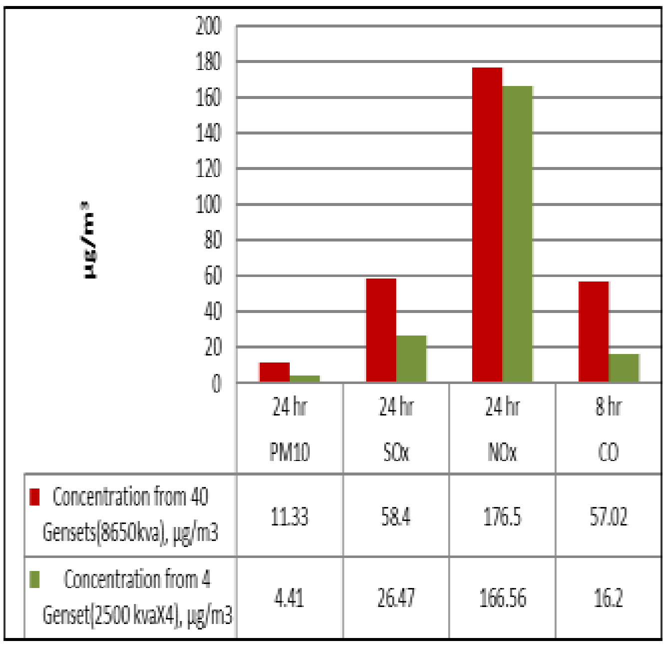

Fig.4. 40 Gensets Concentration Vs. 4 Gensets Concentration

The recommendations so made will assist in improving the air quality scenario around the campus, their prior implementation will decrease load on generators running in and around the campus which will further improve the surrounding air quality.

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