ISSN: 2278-0181
NCRACE-2015 Conference Proceedings

Assessment of Worst Meteorological Situation using Computer Aided SCREEN- SPR Model

Mr. G. Praveen Kumar[1], Dr. S. Mohan[2], Dr. S. Palanivelraja[3]
[1] Research Scholar [2]Associate Professor, [3]Professor
[1,2,3]Department of Civil Engineering,
Annamalai University, Annamalai nagar- 608 002.

Abstract **- Using a Gaussian diffusion equation, a simple computer programme incarnated as SCREEN-SPR Model has been developed in C# language and run on the Visual Basic platform. This is used to calculate the Ground Level Concentration (GLC) of pollutant prevailing at downwind locations ranging from 100 m to 10 km with an increment of 100m under the combinations of various wind speed and atmospheric stability classes. A worst Meteorological situation has been arrived, by which the combinations of particular wind speed and its relevant stability class may possess, the max GLC of the pollutant prevailing at the shortest downwind distance from the stationary source i.e. considered to be a "critical' situation. In any Air Pollution Assessment study, the impact would be assessed with respect to the worst meteorological situation.**

I. INTRODUCTION

Large industrial activities (power generation) and their expansion projects in a limited area, in any air basin may pose many problems, especially "Air Pollution Management". The transport and diffusion of the air pollutants along the downwind distance emitted into the atmosphere from the tall stacks depend on meteorological factors such as wind speed, wind direction and atmospheric turbulence. Rao et al. (1994) defines the critical wind speed (case) is that at which the concentrations of the impurities at the breathing level can attain their maximum in a particular meteorology . Their study focused on determination of critical wind velocities for a Thermal Power plant of capacity 3600MW, based on the Gaussian plume model approach. It employed all possible wind speeds and their relevant stability classes to determine the critical wind speed separately, but his study was limited to 10km only.

This study involves all possible wind speeds (0.25, 0.69, 1.39, 2.10, 2.75, 3.47, ... 16.67) (m/se) and their relevant stability classes to determine the critical wind speed of the programme developed in C language. To run the programme successfully, enter the following variables as an input.

The internal stack diameter (d),
The stack exit gas velocity (Vs),
The physical stack height (his), and
The Emission rate of pollutant (q)

The displayed output consists the each wind speed, and its relevant stability class holds the maximum GLC prevails at a shortest downwind distance.

II. METHODOLOGY

The General Gaussian Dispersion Model has been employed to determine the Groundlevel downwind concentration of the pollutant(Turner 1970). $C(x,0,0)=\frac{Q}{\pi\sigma_y\sigma_z U_{sik}}\exp\left(-\frac{1}{2}\frac{he^2}{2\sigma_z^2}\right)$

Where

C(x,0,0) - Groundlevel downwind centerline concentration of pollutant , ($\mu g/m^3$)

Q -Emission rate of pollutant µg /sec)

Ustk = Mean wind speed at stack height (m/sec)

Effective stack height, he (m)
= physical stack heigh(hs)+plume rise (Ah)

σ_y&σ_z - Diffusion parameters along y & z axes respectively.

Atmospheric Stability

Meteorological conditions defining, Pasquill turbulence types were adopted for determining the atmospheric stability classification,(Pasquill 1961]

Dispersion Characteristics

Formulae recommended by Briggs (1973) for calculating σy(x), σz{x) where10^2<x< 10^4m. This was employed in the dispersion model.

Piume Rise

Briggs formulae were recommended for estimating the plumerise under following conditions.

1. $\Delta h = 2.47\ (Qh)^{1/3}\ (hs)^{2/3}$ for Unstable and Neutral conditions

2. F
h = 2.45 $(Qh/0.0064\ u_{stk})^{1/3}$
for stable conditions:

ISSN: 2278-0181
NCRACE-2015 Conference Proceedings

where

Δh – plume rise in (m)
Qh- Heat emission rate (Kcal/Sec)
hs = Physical stack height (m)

Wind Speed at Stack Level

Often the Wind speed at the stack height are not available and they are evaluated based on the theoretical formula. Wind speed at stack level has been found out using power law

$$U_{stk} \, ; \, U_{10} \, (h_s/h_{10})^p$$

Where

U_{stk} ; wind speed at stack outlet (m/sec)
U_{10}; Wind speed at 10 m level (the standard height for anemometers)
p; is a function of stability p= 0.12 for unstable conditions, p = 0.14 for neutral conditions, p= 0.24 for stable conditions.
Wind speed at stack level was used in the dispersion calculation.

Plant Characteristics

The input data for the model were taken for a typical Thermal power plant generating 360 MW capacity with lignite as fuel.

Physical stack height :275 m
Diameter of the stack at outlet :0.5 m
Atmospheric temperature :41°C
Stack gas temperature :150°C
Exit Velocity of stack gas :25 m/sec
Mass density of stack gas :0.9 kg/m
Specific heat at constant pressure :0.26 k.cal./sec

III.

ESULT & DISCUSSION

The purpose of the present study is to identify the worst meteorological situation leading to maximum ground level concentration. The stability class identification is based on the Pasquiils turbulence types. The combination of various wind speed and the relevant stability classes were employed in these estimates with average wind speed of 0.25 m/sec, 0.69 m/sec, 1.39 m/sec, 2.10-m/sec, 2.75 m/sec, 3.47 m/sec, 4.17 m/sec, 4.87 m/sec, 5.10 m/sec, 5.38 m/sec, 6.94 m/sec. 9.72 m/sec, 12.50 m/sec, 16.67 m/sec. Using the Gaussion diffusion equation, the maximum GLC have been worked out for all the wind speed and its relevant stability class upto a distance of 10,000 m at an interval of 100m.When the SCREEN-SPR programme is run successfully, the resulting values are stored on the data file.Please see Figure-1. The data file contains a critical wind speed corresponding to each stability class, which the combination of wind speed and its corresponding stability class holds the maximum GLC prevailing at the shortest ground level downwind location. That is the worst metrology situation. Table-1 clearly identify the worst meteorological situation for the Typical Thermal Power plant under assumed plant characteristics as the critical wind speed of 3.47m/sec prevailing under stability class B holds the highest GLC at a downwind distance of about 7000 m from the source.

Fig-1: Screen Shot of SCREEN-SPR model

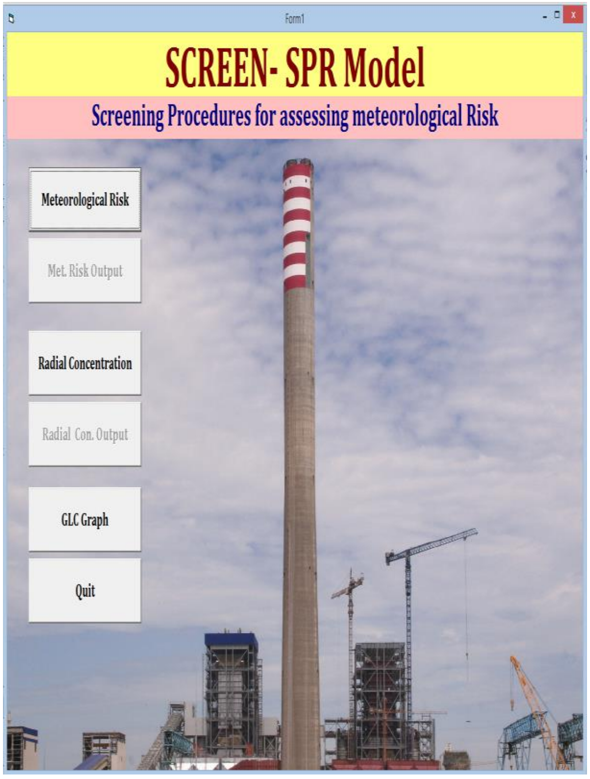

TABLE-1:WORST METEOROLOGICAL SITUATION

Worst meteorological situation

CLASS	X	SY	SZ	UBAR	USTK	EFF. HT	CX
A	10000.00	1555.63	2000.00	0.25	0.37	12016.96	0.000
A-B	10000.00	1343.50	1600.00	0.25	0.37	12016.96	0.000
B	10000.00	1131.37	1200.00	0.25	0.37	12016.96	0.000

CLASS	X	SY	SZ	UBAR	USTK	EFF. HT	CX
A	10000.00	1555.63	2000.00	0.69	1.03	4529.33	17.205
A-B	10000.00	1343.50	1600.00	0.69	1.03	4529.33	5.886
B	10000.00	1131.37	1200.00	0.69	1.03	4529.33	0.413

CLASS	X	SY	SZ	UBAR	USTK	EFF. HT	CX
A	9000.00	1436.44	1800.00	1.39	2.07	2386.86	55.428
A-B	10000.00	1343.50	1600.00	1.39	2.07	2386.86	52.785
B	10000.00	1131.37	1200.00	1.39	2.07	2386.86	35.174

CLASS	X	SY	SZ	UBAR	USTK	EFF. HT	CX
A-B	7800.00	1110.81	1248.00	2.10	3.13	1672.85	67.128
B	10000.00	1131.37	1200.00	2.10	3.13	1672.85	63.699
C	10000.00	777.82	461.88	2.10	3.13	1672.85	0.902
E	10000.00	424.26	75.00	2.10	4.65	605.65	0.000
F	10000.00	282.84	40.00	2.10	4.65	605.65	0.000

Worst Meteorological Situation

CLASS	X	SY	SZ	UBAR	USTK	EFF. HT	CX
B	7000.00	859.00	840.00	3.47	5.16	1120.96	78.673

ISSN: 2278-0181
NCRACE-2015 Conference Proceedings

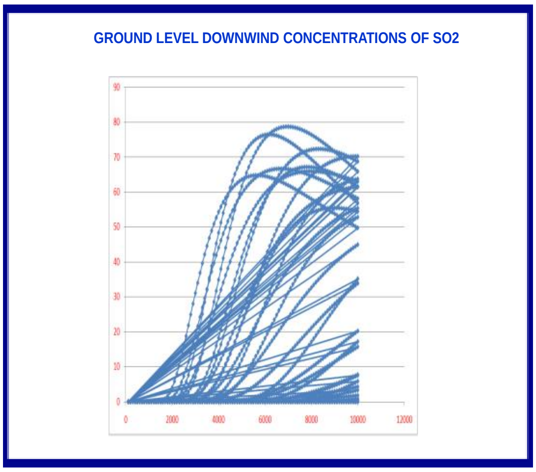

Fig-2: Ground level Downwind concentration of So_2

IV CONCLUSION

The SCREEN-SPR Model has been developed in C# language and run on the Visual Basic platform and it is used to calculate the Ground Level Concentration (GLC) of pollutant prevailing at downwind locations ranging from 100 m to 10 km with an increment of 100m under the combinations of various wind speed and atmospheric stability classes. The worst metrology situation for the typical Thermal Power plant under assumed plant characteristics was the critical wind speed of 3.47m/Sec prevails under stability class B holds the highest GLC at a downwind distance of about 7000 m from the source.

REFERENCES

[1] Briggs, G.A. (1973). Difusion estimation for small emissions, Env. Res. Lab., AirResources Atoms. Turb and Diffusion lab., 1973 annual report, ATDL-106.

[2] Pasquill. F. (1961) The estimation of the dispersion of wind borne material.MET. mag 90, 33-49.

[3] Rao, (1994) . Determination of critical wind velocities for thermal power plants -JA Gaussion plume model approach.

[4] Turner, D.B. 1970 workbook on atmospheric dispersion