

## Comparison Between Actual and Estimated Maximum Downwind Distance using Different Dispersion Parameters

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**Abstract:** In this study, the maximum downwind distance  $x_{\max}$  was calculated according to the dispersion parameters and by using four methods the power law function, standard, Klug and Pasquill-Gifford method sat three effective heights of 5, 100 and 250 m, respectively. The maximum ground level concentration of air pollution that based on the Gaussian model can be calculated by using the estimated and actual values of the  $x_{\max}$  for different stability classes. The estimated and actual  $x_{\max}$  are summarized as 0-492 m in power law and standard method, also the percentage of the error between estimated and actual maximum downwind distance in the range of 0.005-14.2, respectively. Comparison between the results of estimated and actual  $x_{\max}$  in case of power law and standard method with the previous work used Brigg method (Ronbanchob2015) is carried out.

## INTRODUCTION

The main factor of air dispersion modeling is predicting the concentration of pollutant resulting from a point source or multi-sources under various meteorological conditions. These models are useful for studying the transmission of pollutants into the air<sup>[1]</sup>.

The concentration of pollutant is function of many variables including the emission rate, the distance of the receptors from the source and the atmospheric conditions. The atmospheric air quality dispersion model is usually used to estimate the reduction occurring through the transportation of pollutant from any source<sup>[2]</sup>. The most common model for studying the air dispersion process is to improve air quality is generally based on Gaussian

plume/puff formula. There are many parameters on the basis of empirical correlation and as function of distance were originally developed by pasquill and modified by Gifford. The lateral and vertical dispersion parameter, respectively  $\sigma_y$  and  $\sigma_z$  represent the turbulent parameter ization in this approach. They include the physical features that describe the dispersion progression<sup>[3]</sup>.

In this study, the maximum concentration at ground level in center-line is predicted with the maximum downwind distance by using the dispersion parameters by two different methods. One of the most important methods is the power-law functions in which plume dispersion coefficients are articulated according to downwind distance and atmospheric stability<sup>[4]</sup>. While the standard method is based on a single atmospheric stability

firmed by vertical temperature gradient and the analytical expressions based on (P-G) curves<sup>[5]</sup>. A Comparison between the results of estimated and actual  $x_{\max}$  in the case of the power law and standard method with the previous work used Brigg's method<sup>[6]</sup> is carried out.

## MATERIALS AND METHODS

**Mathematical model:** The concentration in the downwind distance can be expressed as Eq. 1 according to Gaussian model<sup>[7]</sup>:

$$c(x, y, z, H) = \frac{q_p}{2\pi\sigma_y\sigma_z u} e^{-\frac{1}{2}\left[\frac{y}{\sigma_y}\right]^2} \left[ e^{-\frac{1}{2}\left[\frac{z-H}{\sigma_z}\right]^2} + e^{-\frac{1}{2}\left[\frac{z+H}{\sigma_z}\right]^2} \right] \quad (1)$$

Where:

$C(x, y, z, H)$  = The concentration in the downwind distance, crosswind and vertical distance at stack height

$H, q_p$  = The emission rate at point source "p"

$\sigma_y, \sigma_z$  = Are crosswind and vertical dispersion parameters

$u$  = The wind speed (m sec<sup>-1</sup>)

Equation 1 can be reduced to simple term at the ground level in the plume centerline as follows:

$$c(x, 0, 0, H) = \frac{q_p}{\pi\sigma_y\sigma_z u} e^{-\frac{1}{2}\left[\frac{H}{\sigma_z}\right]^2} \quad (2)$$

where the variables  $\sigma_y, \sigma_z$  depends on the atmospheric stability classes. The maximum downwind distance and concentration can be derived from the principle of rough estimation by solving equation  $\sigma_z \frac{H}{\sqrt{2}}$ <sup>[7]</sup> using estimated and actual methods, so we used two different methods such as power law and standard methods as follows:

**Power-law functions:** The variables and can be calculated as follows<sup>[8]</sup>:

$$\sigma_y = ax^b \quad (3)$$

$$\sigma_z = cx^d \quad (4)$$

where, a-d are constants values depending on the stability classes (Table 1)<sup>[9]</sup>.

**Standard method:** This model is based on a single atmospheric stability which determined by the vertical temperature gradient,  $\Delta T/Z\Delta$ <sup>[10]</sup> and the dispersion parameters have the form:

Table 1: Constants for calculating lateral ( $\sigma_y$ ) and vertical dispersion parameter ( $\sigma_z$ )

| Constants stability | $\sigma_y$ |      | $\sigma_z$ |      |
|---------------------|------------|------|------------|------|
|                     | a          | B    | C          | d    |
| Very unstable       | 0.40       | 0.91 | 0.41       | 0.91 |
| Unstable            | 0.36       | 0.86 | 0.33       | 0.86 |
| Neutral             | 0.32       | 0.78 | 0.22       | 0.78 |
| Stable              | 0.31       | 0.71 | 0.06       | 0.71 |

Table 2: A correspondence between  $\Delta T/\Delta z, \sigma_0$ , dispersion parameters and Pasquill stability classes

| Pasquill classes                                          | A      | B            | C            | D            | E       |
|-----------------------------------------------------------|--------|--------------|--------------|--------------|---------|
| $\frac{\Delta T}{\Delta z} \left( \frac{K}{100m} \right)$ | <-1.9  | -1.9 to -1.7 | -1.7 to -1.5 | -1.5 to -0.5 | 0.5-1.5 |
| $\sigma_0$                                                | 25°    | 20°          | 15°          | 10°          | 5°      |
| a (km)                                                    | 0.927  | 0.370        | 0.283        | 0.707        | 1.07    |
| s (m/km)                                                  | 102.0  | 96.2         | 72.2         | 47.5         | 33.5    |
| q                                                         | -1.918 | -0.101       | 0.102        | 0.465        | 0.624   |
| r (m/km)                                                  | 250    | 202          | 134          | 78.7         | 56.6    |
| p                                                         | 0.189  | 0.162        | 0.134        | 0.135        | 0.137   |

A correspondence between  $\Delta T/\Delta z, \sigma_0$ , dispersion parameters and Pasquill stability classes

$$\sigma_y = \frac{rx}{\left(1 + \frac{x}{a}\right)^p} \quad (5)$$

$$\sigma_z = \frac{sx}{\left(1 + \frac{x}{a}\right)^q} \quad (6)$$

where, r, s, a, p and q are constants depends on the atmospheric stability (Table 2)<sup>[4]</sup>. Now, one estimates the values of crosswind and vertical standard parameters in power law and standard methods as follows:

**Klug system:** Klug studied a system of diffusion parameters that is applicable for short-term ground level release over terrain with a low surface roughness<sup>[1]</sup> as follows:

$$\sigma_y(x) = p_y x^{q_y} \quad (7)$$

$$\sigma_z(x) = p_z x^{q_z} \quad (8)$$

where, x is the source distance and the coefficient p and q are specified in Table 3 and 4.

**Pasquill-gifford system:** The combination of Pasquill and Gifford parameters is called P-G scheme. In this scheme and are obtained from graphs as a function of downwind distance x, for each stability classes<sup>[11]</sup>:

$$\sigma_y(x) = (a_1 \ln x + a_2) \quad (9)$$

Table 3: Power law and standard method for prediction of  $\sigma_y$  and  $\sigma_z$

| Stability class         | Power law      |                | Standard method                          |                                          |
|-------------------------|----------------|----------------|------------------------------------------|------------------------------------------|
|                         | $\sigma_y$ (m) | $\sigma_z$ (m) | $\sigma_y$ (m)                           | $\sigma_z$ (m)                           |
| A (very unstable)       | $0.4x^{0.91}$  | $0.41x^{0.91}$ | $\frac{0.25x}{1+\frac{0.189x}{0.927}}$   | $\frac{0.102x}{1-\frac{1.918x}{0.927}}$  |
| B (moderately unstable) | $0.4x^{0.91}$  | $0.41x^{0.91}$ | $\frac{0.202x}{1+\frac{0.162x}{0.370}}$  | $\frac{0.0962x}{1-\frac{0.101x}{0.370}}$ |
| C (slightly unstable)   | $0.36x^{0.86}$ | $0.33x^{0.86}$ | $\frac{0.134x}{1+\frac{0.134x}{0.283}}$  | $\frac{0.0722x}{1+\frac{0.102x}{0.283}}$ |
| D (neutral)             | $0.32x^{0.78}$ | $0.22x^{0.78}$ | $\frac{0.0787x}{1+\frac{0.135x}{0.707}}$ | $\frac{0.0475x}{1+\frac{0.465x}{0.707}}$ |
| E (slightly stable)     | $0.31x^{0.71}$ | $0.06x^{0.71}$ | $\frac{0.0566x}{1+\frac{0.137x}{1.07}}$  | $\frac{0.0335x}{1+\frac{0.624x}{1.07}}$  |

Table 4: Coefficients of Klug system for all stability classes (Vogt. 1977)

| Coefficients | A      | B      | C      | D      | E      | F      |
|--------------|--------|--------|--------|--------|--------|--------|
| $p_y$        | 0.4690 | 0.3060 | 0.2300 | 0.2190 | 0.2370 | 0.2730 |
| $q_y$        | 0.9030 | 0.8850 | 0.8550 | 0.7640 | 0.6910 | 0.5940 |
| $p_z$        | 0.0170 | 0.0720 | 0.0760 | 0.1400 | 0.2170 | 0.2620 |
| $q_z$        | 0.3800 | 1.0210 | 0.7270 | 0.7270 | 0.6100 | 0.5000 |

Table 5: Coefficients of Pasquill-Gifford system for all stability classes (Vogt. 1977)

| Coefficients | Stability classes |         |         |         |         |         |
|--------------|-------------------|---------|---------|---------|---------|---------|
|              | A                 | B       | C       | D       | E       | F       |
| $a_1$        | -0.0234           | -0.0147 | -0.0117 | -0.0059 | -0.0059 | -0.0029 |
| $a_2$        | 0.3500            | 0.2480  | 0.1750  | 0.1080  | 0.0880  | 0.0540  |
| $b_1$        | 0.8800            | -0.9850 | -1.1860 | -1.3500 | -2.8800 | -3.800  |
| $b_2$        | 0.1520            | 0.8200  | 0.8500  | 0.7930  | 1.2550  | 1.4190  |
| $b_3$        | 0.1475            | 0.0168  | 0.0045  | 0.0022  | -0.0420 | -0.0550 |

$$\sigma_z(x) = \frac{1}{2.15} \exp(b_1 + b_2 \ln x + b_3 \ln^2 x) \quad (10)$$

where the constants  $a_1$ ,  $a_2$ ,  $b_1$ ,  $b_2$  and  $b_3$  depend on the atmospheric stability and their values are presented in Table 5.

## RESULTS AND DISCUSSION

The actual  $x_{\max}$  of the Gaussian model is determined using programs as a mathematica5 that finds the relation between the ground level concentration and the downwind distance such that there are three effective heights at 5, 100 and 250 m were evaluated using  $q_p$  and  $u$  of  $3 \text{ g sec}^{-1}$  and  $3 \text{ m sec}^{-1}$ , respectively. The percentage of relative error was calculated by:

$$\text{Relative error} = \left| \frac{\text{actual } x_{\max} - \text{estimated } x_{\max}}{\text{actual } x_{\max}} \right| \quad (11)$$

Table 6: Calculation of  $x_{\max}$

| Stability class | $x_{\max}$ power law                                     | $x_{\max}$ standard method |
|-----------------|----------------------------------------------------------|----------------------------|
| A               | $\left( \frac{H}{0.41\sqrt{2}} \right)^{\frac{1}{0.91}}$ | $\frac{H}{0.144+2.07H}$    |
| B               | $\left( \frac{H}{0.41\sqrt{2}} \right)^{\frac{1}{0.91}}$ | $\frac{H}{0.136+0.27H}$    |
| C               | $\left( \frac{H}{0.33\sqrt{2}} \right)^{\frac{1}{0.86}}$ | $\frac{H}{0.102-0.360H}$   |
| D               | $\left( \frac{H}{0.22\sqrt{2}} \right)^{\frac{1}{0.78}}$ | $\frac{H}{0.067-0.657H}$   |
| E               | $\left( \frac{H}{0.06\sqrt{2}} \right)^{\frac{1}{0.71}}$ | $\frac{H}{0.047-0.58H}$    |

The calculation of  $x_{\max}$  which depends on the dispersion parameters can be estimated from Table 6. The prediction of maximum values  $x_{\max}$  depend on input values which are given in Table 7-10 one concludes that from four tables, the maximum value of downwind distance depends on stability classes and the effective height of point source, one finds that from the four tables, there are well agreement between actual and estimated values of maximum downwind distance.

In power law, standard method, Klug and Pasquill-Gifford systems, one finds that the percentage of the error between estimated and actual maximum downwind distance in the range of 0-492, 0.005-14.2, 0.73-6.7 and 0.23-94.9, respectively. This research shows that when we used the method of the power law, standard method, Klug and Pasquill-Gifford system are better than Brigg's model method with respect to the presented error<sup>[6]</sup>. Then one can deduce that the best values for the estimation  $x_{\max}$  be observed at the lower  $x_{\max}$  value.

Figure 1 and 2 show the variation of the maximum estimated and actual downwind distance in power law and standard methods. We can conclude that the maximum estimated and actual downwind distances using standard method are better than using power law method but the power law method is a well agreement in all stabilities except stable condition.

Table 9 and 10 show that the estimated of  $c_{\max}$  which depend on the maximum downwind distance, effective stack height and stability classes. One finds that the errors are in the range of 0-15.38 and 3.1-290 for power law function and standard method, respectively.

Figure 3 and 4 show the variation of absolute maximum estimated and absolute maximum ground

Table 7: Accuracy for the calculation of  $x_{\max}$  by using power law function

| Stability class | H = 5<br>actual<br>$x_{\max}$ (m) | H = 5<br>estimated<br>$x_{\max}$ (m) | H = 5<br>relative<br>error (%) | H = 100<br>actual<br>$x_{\max}$ (m) | H = 100<br>estimated<br>$x_{\max}$ (m) | H = 100<br>actual<br>error (%) | H = 250<br>relative<br>$x_{\max}$ (m) | H=250<br>estimated<br>$x_{\max}$ (m) | H = 250<br>relative<br>error (%) |
|-----------------|-----------------------------------|--------------------------------------|--------------------------------|-------------------------------------|----------------------------------------|--------------------------------|---------------------------------------|--------------------------------------|----------------------------------|
| A               | 11                                | 11                                   | 0                              | 300                                 | 287                                    | 4.33                           | 1000                                  | 786                                  | 21.4                             |
| B               | 11                                | 11                                   | 0                              | 300                                 | 287                                    | 4.33                           | 1000                                  | 786                                  | 21.4                             |
| C               | 14                                | 16                                   | 14.3                           | 500                                 | 513                                    | 2.6                            | 2000                                  | 1489                                 | 25.55                            |
| D               | 45                                | 35                                   | 22.22                          | 1400                                | 1637                                   | 16.92                          | 5000                                  | 5301                                 | 6.02                             |
| E               | 400                               | 311                                  | 22.25                          | 15000                               | 21174                                  | 41.16                          | 13000                                 | 76966                                | 492                              |

Table 8: Accuracy for the calculation of  $x_{\max}$  by standard method

| Stability class | H = 5<br>actual<br>$x_{\max}$ (m) | H = 5<br>estimated<br>$x_{\max}$ (m) | H = 5<br>relative<br>error (%) | H = 100<br>actual<br>$x_{\max}$ (m) | H = 100<br>estimated<br>$x_{\max}$ (m) | H = 100<br>actual<br>error (%) | H = 250<br>relative<br>$x_{\max}$ (m) | H=250<br>estimated<br>$x_{\max}$ (m) | H = 250<br>relative<br>error (%) |
|-----------------|-----------------------------------|--------------------------------------|--------------------------------|-------------------------------------|----------------------------------------|--------------------------------|---------------------------------------|--------------------------------------|----------------------------------|
| A               | 0.482                             | 0.476463                             | 1.15                           | 0.483                               | 0.482756                               | 0.05                           | 0.483                                 | 0.482957                             | 0.005                            |
| B               | 3.50                              | 3.34225                              | 4.5                            | 3.64                                | 3.65818                                | 0.5                            | 3.66                                  | 3.66913                              | 0.25                             |
| C               | -2.90                             | -2.94464                             | 1.54                           | -2.78                               | -2.78567                               | 0.2                            | -2.78                                 | -2.78093                             | 0.03                             |
| D               | -1.51                             | -1.55376                             | 2.9                            | -1.52                               | -1.52362                               | 0.24                           | -1.52                                 | -1.52269                             | 0.17                             |
| E               | -1.71                             | -1.75254                             | 14.2                           | -1.71                               | -1.725                                 | 0.87                           | -1.71                                 | -1.7247                              | 0.85                             |

Table 9: Accuracy for the calculation of  $x_{\max}$  by using Klug system

| Stability class | H = 5<br>actual<br>$x_{\max}$ (m) | H = 5<br>estimated<br>$x_{\max}$ (m) | H = 5<br>relative<br>error (%) | H = 100<br>actual<br>$x_{\max}$ (m) | H = 100<br>estimated<br>$x_{\max}$ (m) | H = 100<br>actual<br>error (%) | H = 250<br>relative<br>$x_{\max}$ (m) | H=250<br>estimated<br>$x_{\max}$ (m) | H = 250<br>relative<br>error (%) |
|-----------------|-----------------------------------|--------------------------------------|--------------------------------|-------------------------------------|----------------------------------------|--------------------------------|---------------------------------------|--------------------------------------|----------------------------------|
| A               | 51                                | 47.83                                | 6.2                            | 449                                 | 419.27                                 | 6.6                            | 872.5                                 | 814.43                               | 6.7                              |
| B               | 47                                | 45.33                                | 3.6                            | 882                                 | 852.33                                 | 3.4                            | 2163                                  | 2091.05                              | 3.3                              |
| C               | 79.5                              | 78.92                                | 0.73                           | 2403                                | 2384.12                                | 0.79                           | 6814.5                                | 6761.56                              | 0.78                             |
| D               | 83.5                              | 84.9                                 | 1.7                            | 5140.5                              | 5230.1                                 | 1.7                            | 18129                                 | 18445.2                              | 1.7                              |
| E               | 92                                | 97.02                                | 5.5                            | 12497.5                             | 13173.9                                | 5.4                            | 56129.5                               | 59166.3                              | 5.4                              |

Table 10: Accuracy for the calculation of  $x_{\max}$  by using Pasquill-Gifford system

| Stability class | H = 5<br>actual<br>$x_{\max}$ (m) | H = 5<br>estimated<br>$x_{\max}$ (m) | H = 5<br>relative<br>error (%) | H = 100<br>actual<br>$x_{\max}$ (m) | H = 100<br>estimated<br>$x_{\max}$ (m) | H = 100<br>actual<br>error (%) | H = 250<br>relative<br>$x_{\max}$ (m) | H=250<br>estimated<br>$x_{\max}$ (m) | H = 250<br>relative<br>error (%) |
|-----------------|-----------------------------------|--------------------------------------|--------------------------------|-------------------------------------|----------------------------------------|--------------------------------|---------------------------------------|--------------------------------------|----------------------------------|
| A               | 9.85                              | 10.20                                | 3.6                            | 132.6                               | 122.76                                 | 7.4                            | 231.7                                 | 213.71                               | 7.8                              |
| B               | 31.05                             | 30.98                                | 0.23                           | 667                                 | 645.73                                 | 3.2                            | 1605                                  | 1542.80                              | 3.9                              |
| C               | 40.40                             | 40.80                                | 1.0                            | 1159.2                              | 1145.19                                | 1.2                            | 3171                                  | 3107.56                              | 2.0                              |
| D               | 64.55                             | 67.42                                | 4.4                            | 2537.1                              | 2607.76                                | 2.8                            | 7696.5                                | 7864.84                              | 2.2                              |
| E               | 101.10                            | 102.28                               | 1.2                            | 6368.5                              | 8285.11                                | 30.1                           | 41722.5                               | 81308.53                             | 94.9                             |

Table 11: Accuracy of the calculation of  $C_{\max}$  by using power law method

| Stability class | H = 5<br>actual $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 5<br>estimated $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 5<br>relative<br>error (%) | H = 100<br>actual $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 100<br>estimated $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 100<br>actual<br>error (%) | H = 250<br>relative $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H=250<br>estimated $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 250<br>relative<br>error (%) |
|-----------------|----------------------------------------------------------|-------------------------------------------------------------|--------------------------------|------------------------------------------------------------|---------------------------------------------------------------|--------------------------------|--------------------------------------------------------------|-------------------------------------------------------------|----------------------------------|
| A               | 96                                                       | 96                                                          | 0                              | 0.24                                                       | 0.24                                                          | 0                              | 0.035                                                        | 0.035                                                       | 0                                |
| B               | 96                                                       | 96                                                          | 0                              | 0.24                                                       | 0.24                                                          | 0                              | 0.035                                                        | 0.035                                                       | 0                                |
| C               | 84                                                       | 85.8                                                        | 2.14                           | 0.21                                                       | 0.21                                                          | 0                              | 0.0307                                                       | 0.03                                                        | 2.28                             |
| D               | 60.3                                                     | 64.37                                                       | 6.74                           | 0.1608                                                     | 0.1609                                                        | 0.06                           | 0.0256                                                       | 0.0256                                                      | 0                                |
| E               | 17                                                       | 18.12                                                       | 6.58                           | 0.039                                                      | 0.0453                                                        | 15.38                          | $9.21 \times 10^{-7}$                                        | $9.21 \times 10^{-7}$                                       | 0                                |

Table 12: Accuracy of the calculation of  $C_{\max}$  standard method

| Stability class | H = 5<br>actual $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 5<br>estimated $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 5<br>relative<br>error (%) | H = 100<br>actual $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 100<br>estimated $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 100<br>actual<br>error (%) | H = 250<br>relative $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H=250<br>estimated $C_{\max}$<br>$10^{-4}(\text{g m}^{-3})$ | H = 250<br>relative<br>error (%) |
|-----------------|----------------------------------------------------------|-------------------------------------------------------------|--------------------------------|------------------------------------------------------------|---------------------------------------------------------------|--------------------------------|--------------------------------------------------------------|-------------------------------------------------------------|----------------------------------|
| A               | 1545.50                                                  | 2950                                                        | 290                            | 159.253                                                    | 42.783                                                        | 73.13                          | 1.56611                                                      | 0.35898                                                     | 77                               |
| B               | 1212.28                                                  | 1249.9                                                      | 3.1                            | 38.9136                                                    | 41.563                                                        | 6.8                            | 23.627                                                       | -26.807                                                     | 213                              |
| C               | 368.313                                                  | 324.175                                                     | 11.98                          | 16.3842                                                    | 7.3607                                                        | 55.07                          | 1.27759                                                      | 0.49106                                                     | 61.5                             |
| D               | 1625.53                                                  | -1804.4                                                     | 211                            | 68.5025                                                    | -8.1635                                                       | 111.9                          | 45.7823                                                      | 0.000718                                                    | 99.9                             |
| E               | 1204.35                                                  | -1603.9                                                     | 233                            | 0.010702                                                   | -0.000968                                                     | 109                            | $2.7 \times 10^{-29}$                                        | -5.25                                                       | $1.94 \times 10^{-29}$           |

concentration  $10^{-4}(\text{g m}^{-3})$  in Power law and standard methods. We can conclude that the maximum estimated and absolute maximum ground concentration using power law method is better than using standard. This work shows that when we used the method of the power law,

standard method, Klug and Pasquill-Gifford system are better than Brigg's model method with respect to the presented error<sup>[6]</sup>. Then one can deduce that the best values for the estimation  $x_{\max}$  be observed at the lower  $x_{\max}$  value (Fig. 5 and 6).

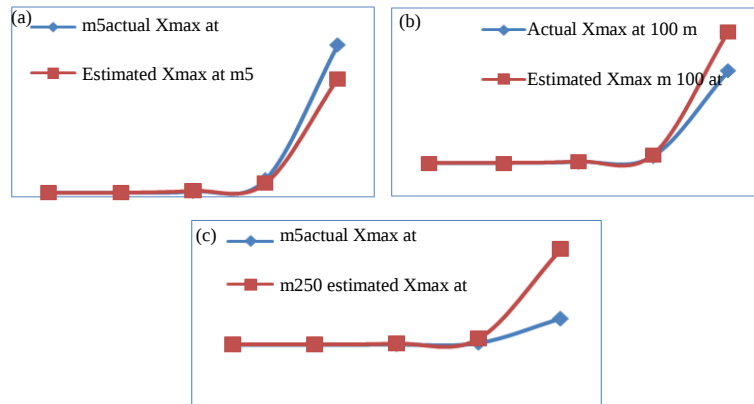


Fig. 1: The variation of the maximum estimated and actual downwind distance (m) using power law

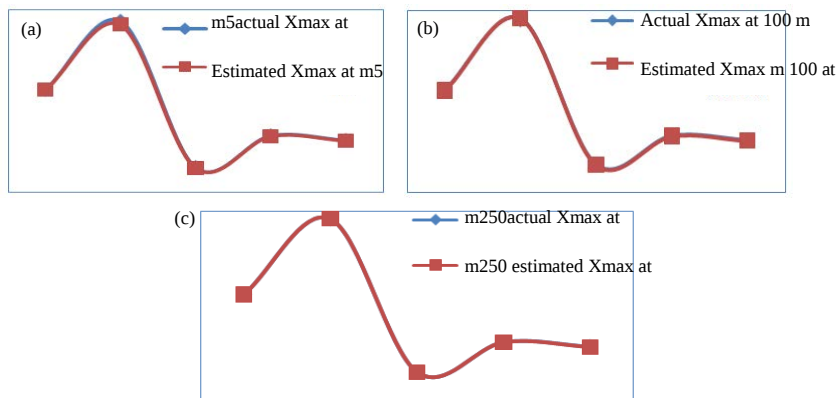


Fig. 2: The variation of the maximum estimated and actual downwind distance (m) in the standard method

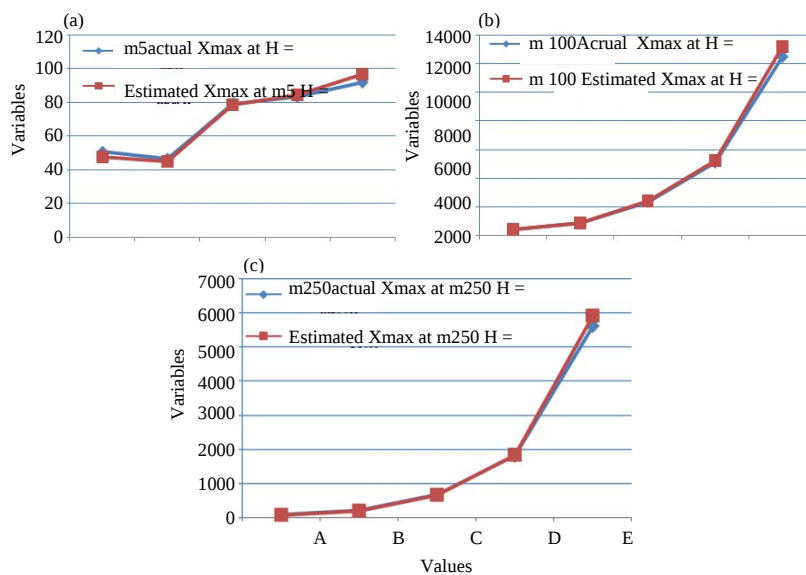


Fig. 3: The variation of the maximum estimated and actual downwind distance (m) in the Klug system

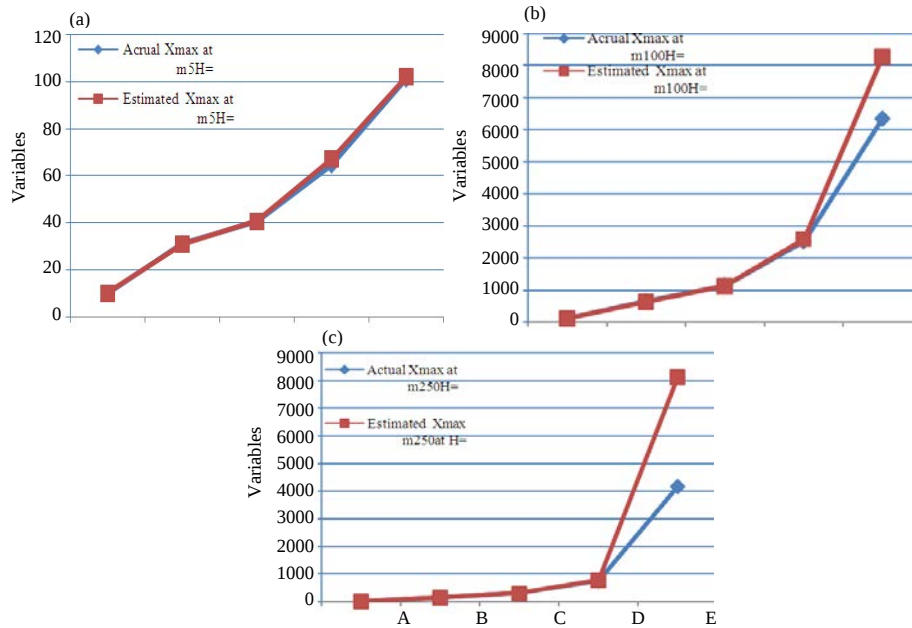


Fig. 4: The variation of the maximum estimated and actual downwind distance (m) in the Pasquill-Gifford system

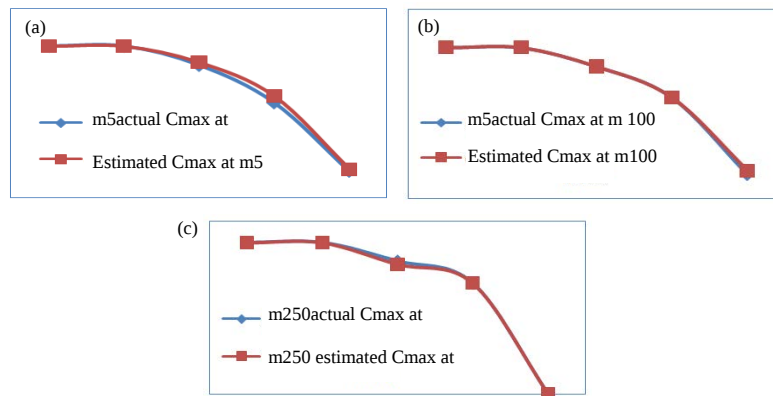


Fig. 5: The variation of absolute maximum estimated and absolute maximum ground concentration  $10^{-4}(\text{g}/\text{m}^3)$  in Power law

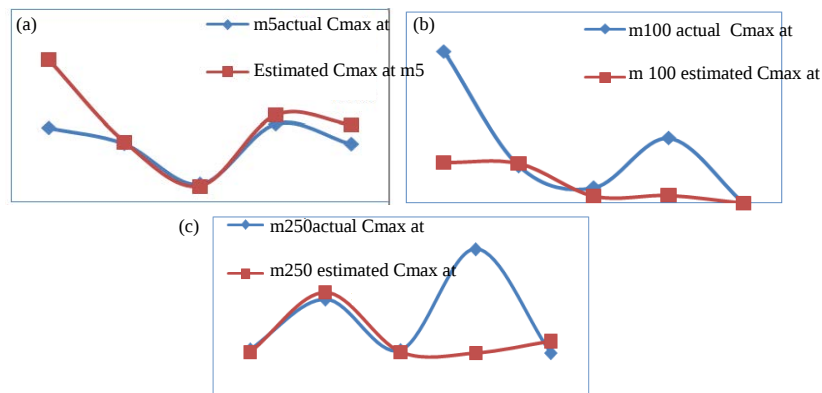


Fig. 6: The variation of maximum estimated and actual maximum ground concentration  $10^{-4}(\text{g}/\text{m}^3)$  in standard method

## CONCLUSION

In this study, the dispersion parameter and can be calculated by using four methods the power law, standard methods, Klug and Pasquill-Gifford systems at three effective height at 5, 100 and 250 m, respectively to calculate the maximum downwind distance and ground level concentration for the emission of air pollutants at point source based on Gaussian model. One finds that the percentage of the error between estimated and actual maximum downwind distance in the range of 0-492, 0.005-14.2, 0.73-6.7 and 0.23-94.9, respectively and the error in the previous work [6] in the range of 0-2713.3%. This work shows that when we used the method of power law, standard methods, Klug and Pasquill-Gifford systems are better than Brigg's model method with respect to the presented error. Then one can deduce that the best values for the estimation  $x_{\max}$  be observed at the lower  $x_{\max}$  value and vice versa.

For the maximum concentration, one finds that the errors are in the range of 0-15.38 and 3.1-290 in power law and standard methods respectively. Also from the figures, we conclude that the estimated and actual maximum downwind distances are in good agreement in all stabilities except stable condition for power law method than standard method.

## REFERENCES

01. Essa, K.S.M. and S.E.M. Elsaid, 2015. Estimation of the maximum concentration for non-gaussian under using different schemes of dispersion parameters for isotopes. *J. Civil Environ. Eng.*, 5: 1-6.
02. Wang, J.S., T.L. Chan, C.S. Cheung, C.W. Leung and W.T. Hung, 2006. Three-dimensional pollutant concentration dispersion of a vehicular exhaust plume in the real atmosphere. *Atmos. Environ.*, 40: 484-497.
03. Abdel-Wahab, M.M., K.S. Essa, M. Embaby and S.E. Elsaid, 2013. Derivation the schemes of lateral and vertical dispersion parameters: Application in gaussian plume model. *Open J. Air Pollut.*, 2: 19-24.
04. Sharan, M., A.K. Yadav and M.P. Singh, 1995. Comparison of sigma schemes for estimation of air pollutant dispersion in low winds. *Atmos. Environ.*, 29: 2051-2059.
05. Essa, K.S.M., F. Mubarak and S.A. Khadra, 2005. Comparison of some sigma schemes for estimation of air pollutant dispersion in moderate and low winds. *Atmos. Sci. Lett.*, 6: 90-96.
06. Apiratikul, R., 2015. Approximation formula for the prediction of downwind distance that found the maximum ground level concentration of air pollution based on the gaussian model. *Procedia Soc. Behav. Sci.*, 197: 1257-1262.
07. Kenneth, W. and F.W. Cecil, 1972. *Air Pollution its Original and Control*. Adun-Donnelly Publisher, New York, USA.,.
08. Essa, K.S.M., F. Mubarak and S.E. Elsaid, 2006. Effect of the plume rise and wind speed on extreme value of air pollutant concentration. *Meteorol. Atmos. Phys.*, 93: 247-253.
09. Sellers, B.H., 1989. An analytical representation for the pasquill-gifford-turner oz curves for elevated sources. *Atmosfera*, 2: 111-124.
10. Green, A.E.S., R.P. Singhal and R. Venkateswar, 1980. Analytic extensions of the Gaussian plume model. *J. Air Pollut. Control Assoc.*, 30: 773-776.
11. Till, J.E. and H.R. Meyer, 1983. *Radiological Assessment: A Textbook on Environmental dose Analysis*. Oak Ridge National Lab, Tennessee, USA., Pages: 950.