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# INFLUENCE OF SURROUNDING TERRAIN HEIGHT ON AIR DISPERSION OF POINT SOURCE EMISSIONS

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**Abstract:** This paper aims to analyze the influence of topographic factors on the Gaussian air dispersion model of a gaseous pollutant emitted by a point source. Thus, both elevated terrain composed of three sections (35 m, 50 m and 60 m above the stack base) and flat terrain conditions were implemented in the ScreenView model. The results are presented as variations in ground-level pollutant concentration versus the distance from the stack of 5 km.

**Keywords:** air dispersion model, ScreenView, terrain height, point source, pollutant

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## 1. INTRODUCTION

Air dispersion of pollutants emitted by point sources is influenced by several factors, among which are listed: chemical and physical pollutant properties, geometric characteristics of the emission source, dispersion medium properties and receptor properties [1, 2]. The latter category, in addition to the distance from the emission source, refers to the topography of the surrounding terrain. Clearly, for the same pollutant emission rate, the concentration estimated at ground level may be different in high-altitude areas, deep valleys, wavy areas, in wooded areas or on water surfaces [1, 2].

The air dispersion of the Gaussian plume model gives the analytical solution to the following equation [1, 2]:

$$C(x,y,z)=\frac{Q}{2\pi\cdot\sigma_y\cdot\sigma_z\cdot v_v}\cdot\exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]\cdot\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right]+\exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\} \qquad (1)$$

where: C [g/m$^3$] is the concentration of the pollutant, Q [g/s] is the pollutant emission rate, $\sigma_y$ and $\sigma_z$ [m] are the dispersion coefficients or standard deviations, $v_v$ [m/s] is the wind velocity, y and z [m] are the coordinate distances from the source, $H=h+\Delta h$ [m] is the stack effective height. Figure 1 shows the parameters of the Gaussian plume model [2].

In addition to the input data of the air dispersion models, several options were incorporated to take into account the topography of the surrounding terrain [3, 4]. For example, the ScreenView model has the "complex terrain" option to estimate the pollutant concentration at ground level for cases where the receptor is represented by a terrain elevated above the geometric height of the stack. The option of "simple elevated terrain" considers terrain heights that are below the stack build height [3, 4].

The objective of this study is to evaluate the concentration of gaseous pollutants at ground level using the "simple elevated terrain" option in the ScreenView software and compare it with the results considering flat terrain. It is presented a case study of NO emission from a cement plant situated in a hilly area. Therefore, conclusions can be drawn about the influence of the point source surrounding terrain height on pollutant air dispersion.

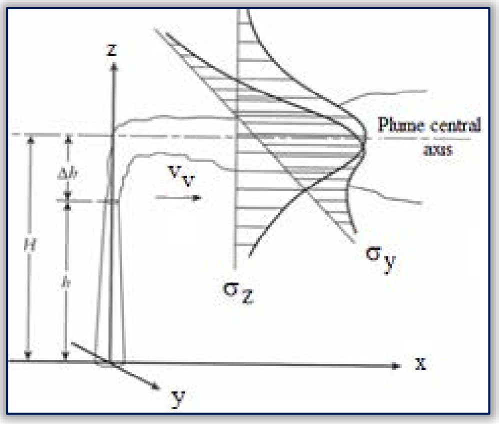

Figure 1. Gaussian plume model parameters [2]

## 2. CASE STUDY

This case study refers to NO emission from a cement plant and how the height of the surrounding terrain influences its air dispersion and thus the value of ground level concentration. Estimates by ScreenView software have been made on a distance of 5 km from the source considering a hilly area next to the emission stack. In addition, to compare the results, a flat terrain is also considered.

Figure 2 shows the heights considered for the terrain surrounding the pollutant emission source. Three sections of terrain height were chosen, i.e. 35 meters above the stack base on a distance from stack between 200 meters and 1 km, next, 50 meters height for a distance up to 3 km, followed by a height of 60 meters up to 5 km distance. These values were set by the "simple elevated terrain" option of the ScreenView software.

Other input numerical data for the model are: $C_{NO}$ = 480.37 mg/m$^3$ is the NO concentration emitted by the furnace stack; Q = 409520 m$^3$/h (113.76 m$^3$/s) is the effluent flow rate; $t_g$ = 150 ºC is the effluent temperature [5].

The pollutant rate of emission $\dot{m}$ in [g/s] may be estimated by formula [6]:

$$C\left[\frac{mg}{m^3}\right] = \frac{\dot{m}\left[\frac{mg}{s}\right]}{Q\left[\frac{m^3}{s}\right]} \qquad (2)$$

results $\dot{m}$ = 54646.9 mg/s = 54.65 g/s NO.

The geometric dimensions of the stack are: H = 140 m is the built height; d = 4.4 m is the diameter at the top [5]. The effluent velocity was estimated at 7.5 m/s knowing Q and the cross-sectional area of the stack. In addition to terrain height, air temperature was set as a variable, with values of 5 ºC, 10 ºC and 20 ºC, respectively.

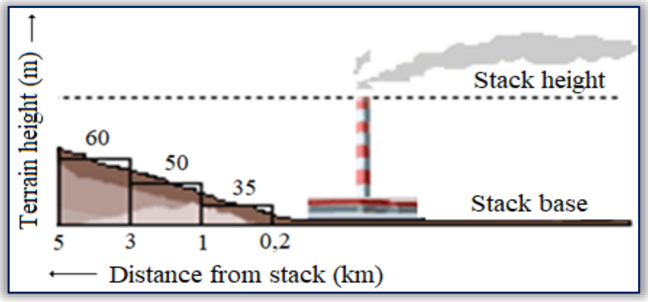

Figure 2. Considered height of the terrain surrounding the pollutant emission source (stack)

## 3. RESULTS AND DISCUSSIONS

### — Elevated terrain

For analyzing the influence of the terrain height surrounding the pollutant emission source on gaseous pollutants dispersion, the NO concentration is plotted versus distance from the source and shown in Figures 3-5. The graphs are represented for each of the three sections of the elevated terrain, at air temperatures of 5 ºC, 10 ºC and 20 ºC, respectively.

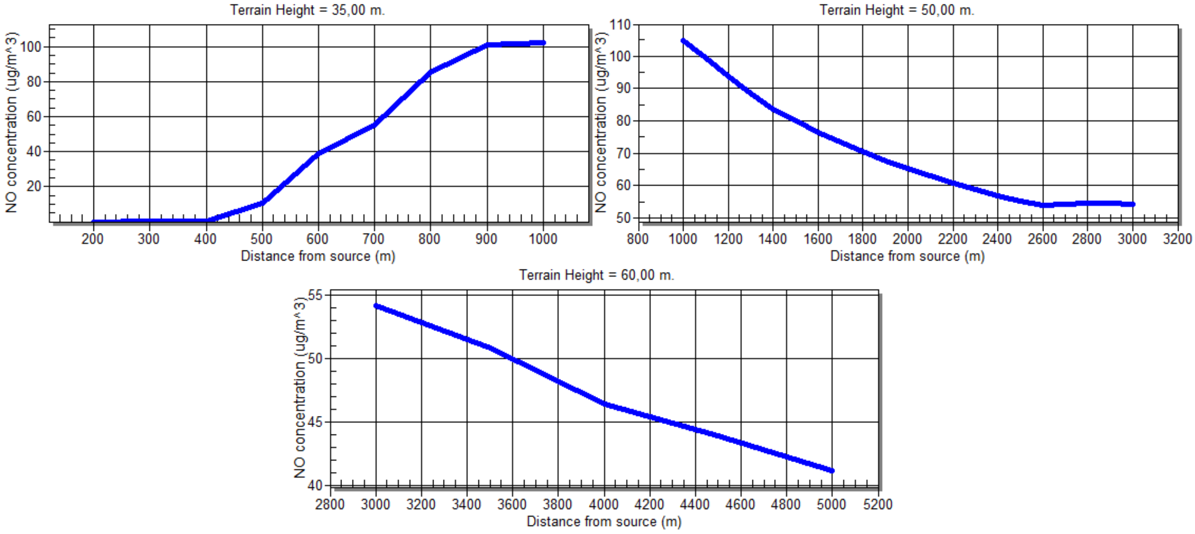

Figure 3. NO concentration in (μg/m$^3$) versus downwind distance from stack in (m), terrain height of 35 m, 50 m and 60 m, at an air temperature of 5 ºC

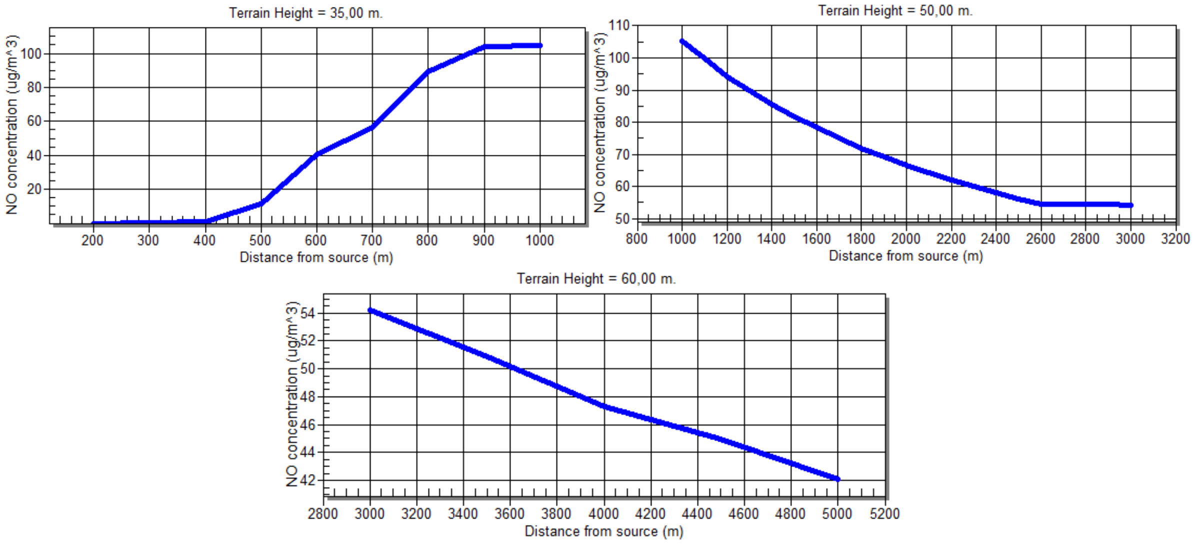

Figure 4. NO concentration in (μg/m$^3$) versus downwind distance from stack in (m), terrain height of 35 m, 50 m and 60 m, at an air temperature of 10 ºC

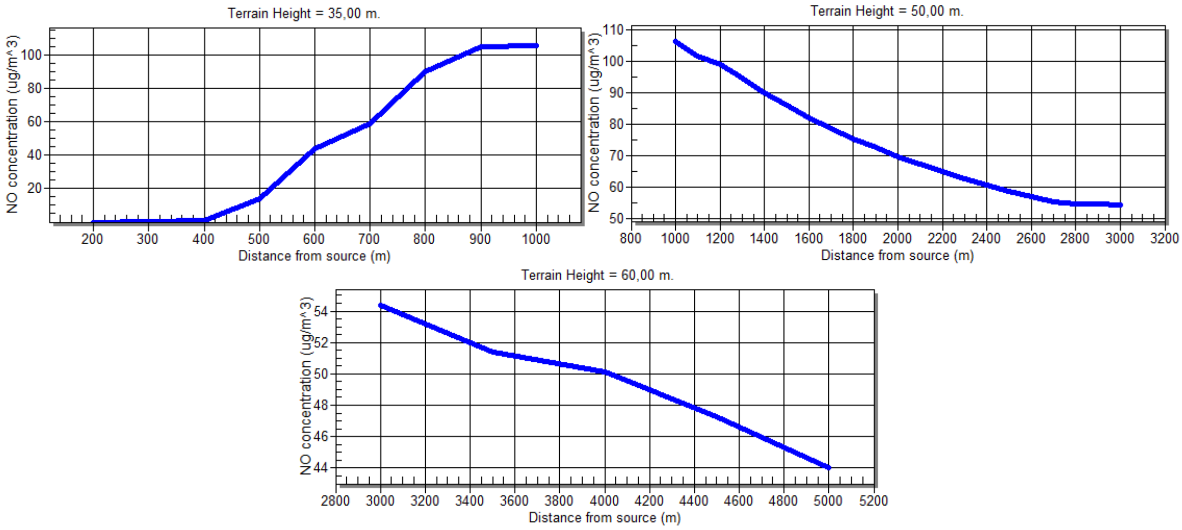

Figure 5. NO concentration in (μg/m$^3$) versus downwind distance from stack in (m),
terrain height of 35 m, 50 m and 60 m, at an air temperature of 20 ºC

From the results presented in graphs 3-5, depending on the atmospheric air temperature, the maximum concentration values of NO at ground level are determined and listed in Table 1. Is considered all 5 km of elevated terrain from the stack and pollutant max. concentration values are reported for 5 ºC, 10 ºC and 20 ºC, respectively. Also, in Table 1 are given the values of both the terrain height and the distance from stack where this concentration is estimated.

Table 1. Results estimated by ScreenView of NO maximum concentration
(in correlation with Figures 3-5)

| NO max. concentration (μg/m$^3$) | Air temperature (ºC) | Terrain height with max. conc. (m) | Distance from the stack with max. conc. (m) |
|---|---|---|---|
| 104.80 | 5 | 35 | 1000 |
| 105.80 | 10 | 35 | 954 |
| 107.10 | 20 | 35 | 952 |

Small variations in concentration are observed as a function of air temperature variation. Also, all maximum values are estimated in the first 1000 meters from the source at a terrain height of 35 m.

— **Flat terrain**

Next, NO concentration estimates are made considering a flat terrain surrounding the emission source. Figures 6-8 show the variation of the NO concentration versus the distance from the stack at the atmospheric air temperature of 5 ºC, 10 ºC and 20 ºC, respectively.

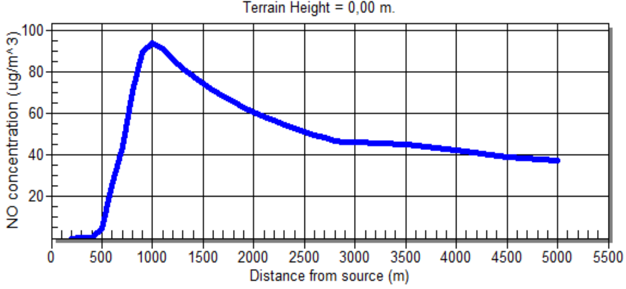

Figure 6. NO concentration in (μg/m$^3$) versus downwind distance from stack in (m),
flat terrain, at an air temperature of 5 ºC

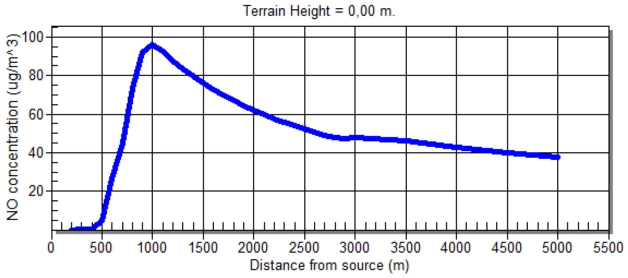

Figure 7. NO concentration in (μg/m$^3$) versus downwind distance from stack in (m),
flat terrain, at an air temperature of 10 ºC

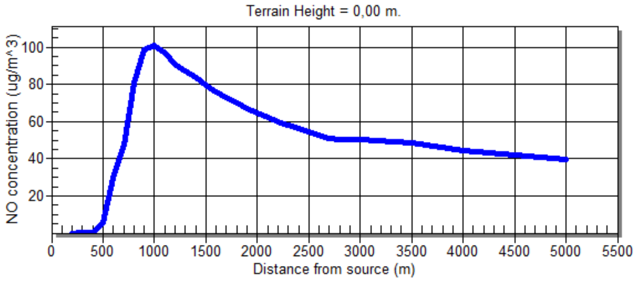

Figure 8. NO concentration in (μg/m$^3$) versus downwind distance from stack in (m), flat terrain, at an air temperature of 20 ºC

In the case of flat terrain, the maximum NO concentration values were also estimated as a function of air temperature. The results obtained by the ScreenView software are given in Table 2 also with the distance from the source where the concentration is maximum.

Table 2. Results estimated by Screen View of NO maximum concentration (in correlation with Figures 6-8)

| NO max. concentration (μg/m$^3$) | Air temperature (ºC) | Distance from the stack with max. conc. (m) |
|---|---|---|
| 93.93 | 5 | 995 |
| 96.28 | 10 | 988 |
| 101.40 | 20 | 972 |

Compared to the values of NO max. concentrations estimated as a function of terrain height (Table 1), in the case of flat terrain, they are lower (Table 2). This may be explained by the increase in buoyancy undisturbed by the surroundings, which favors air dispersion.

Moreover, for flat terrain, the influence of increasing air temperature is clear from the increasing concentration values with the decrease in the distance from the source (see the values in Table 2). This variation is expected as the buoyancy is influenced by the temperature difference of the pollutant emerging stack vs. the surrounding air. As the temperature difference decreases, the buoyancy decreases and the pollutant is deposited at the ground level in higher concentration [1, 7]. As in the case of elevated terrain, NO max. concentration is estimated in the first 1000 m from the stack (see the values in Table 2).

## 4. CONCLUSIONS

This study presents an analysis of the influence of the terrain topography surrounding the emission point source and the atmospheric air temperature on gaseous pollutants air dispersion. Quantitative estimations of the NO concentration values at ground level were made using the Screen View software. Compared to flat terrain, in the case of elevated terrain, the pollutant concentration values were slightly higher, but the effect of buoyancy induced by air temperature was less observed.

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ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

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