

A Basic Computer Program for the Gaussian Equation for a Point Source

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Many readers now are using microcomputers in their work. The advantages of these inexpensive and powerful tools are being recognized by both industry and universities. Microcomputers can be used in lengthy calculations, simulations, data collection and handling, and word processing.

Programming these computers can be done in numerous languages such as Basic, Fortran and Pascal. It is often possible to find commercial programs or software available to handle a given application. There are a growing number of programs published which are now in the public domain. Only a limited number of programs dealing with air pollution problems are available ready for use with a microcomputer.

This note describes a Basic program that uses the Gaussian Equation. It was written specifically for an Apple II Plus computer, but with minor modifications can be used with other microcomputers using Basic.

Program Description

The complete program listing is available from the author. (Please send self-addressed stamped envelope.) Receptor concentration at location (x,y,z) downwind of a point source, having an emission rate of Q grams per second, is estimated using the equation

$$CN(x,y,z) = \frac{Q}{2\pi SY \cdot SZ \cdot U} \exp\left[-\frac{1}{2}\left(\frac{y}{SY}\right)^2\right] \times \left\{ \exp\left[-\frac{1}{2}\left(\frac{Z-H}{SZ}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{Z+H}{SZ}\right)^2\right] \right\} \quad (1)$$

The original work for this Gaussian equation can be found in the literature.¹⁻³

Dispersion parameters SY and SZ in this program are approximated using the equations given by Green *et al.*⁴ and written below as Eq. 2 and 3. The values of a , K , L , q and p were taken from Green's paper.

$$SZ = \frac{Lx}{[1 + (x/a)]^q} \quad (2)$$

$$SY = \frac{Kx}{[1 + (x/a)]^p} \quad (3)$$

To calculate the effective stack height it is necessary to estimate the plume rise. Holland's equation described by Turner³ and given below as Eq. 4 was used to estimate the plume rise for neutral stability.

$$DH = \frac{VE \cdot D}{U} \left[1.5 + 2.68 \times 10^{-3} PS \cdot \frac{(TS - TA)}{TS} \cdot D \right] \quad (4)$$

If either unstable or stable conditions exist it is necessary to modify Eq. 4.

Near the end of the program it is possible to estimate the wind speed at a height equal to the effective stack height. This result can then be used to recalculate the pollutant concentration at the receptor's location.

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Table I presents nomenclature and Table II shows the steps involved in the calculation by this program. A sample calculation is included in Appendix A.

Conclusions

It is possible to carry out involved calculations rapidly with today's microcomputers. The software is just now becoming available to use this powerful tool to solve air pollution control problems.

Table I. Nomenclature.

CN	= Pollutant concentration at x , y , and z , g/m^3
D	= Stack diameter, m
DH	= Plume rise, m
H	= EH = Effective stack height, m
PH	= Physical stack height, m
PS	= Atmospheric pressure, m bar
Q	= Emission rate-point source, g/s
ST	= Stability, 1 through 6
SY	= Dispersion coefficient in y direction, m
SZ	= Dispersion coefficient in z direction, m
TA	= Atmospheric temperature, °K
TS	= Stack exit temperature, °K
U	= Wind speed at $z = H$, m/s
VE	= Stack gas velocity at exit, m/s
x	= XD = receptor distance downwind, m
y	= Receptor distance from centerline, m
z	= Receptor distance above ground, m

Table II. Computer flow diagram.

- Load program
- Input x , y , z , Q , U
- Calculate SY , SZ
- Calculate H
- Calculate CN
- Calculate U at H

References

1. F. Pasquill, "The estimation of the dispersion of wind blown material," *Meteorological Magazine* 90: 33 (1961).
2. F. A. Gifford, "The use of routine meteorological observations for estimating atmospheric dispersion," *Nuclear Safety* 2: 47 (1961).
3. D. B. Turner, "Workbook of Atmospheric Dispersion Estimates," U.S. Public Health Service Pub. 999-AP-26, revised, 1970.
4. A. E. S. Green, *et al.*, "Analytical extensions of the Gaussian plume model," *JAPCA* 30: 773 (1980).

Appendix A. Sample run of program to estimate dispersion from a point source.

Input	Output
$y = 0$	$SZ = 31.5$
$XD = 1000$	$SY = 69.9$
$z = 0$	$H = 192.2$
$Q = 1000$	$CN = 1.985 \times 10^{-10}$
$U = 6$	
$PS = 1013$	
$TA = 298$	
$TS = 350$	
$PH = 100$	
$ST = 4$	
$VE = 10$	
$D = 10$	