Air pollution computer model program development[#]

Ertuğrul ESMERAY[1], Celalettin ÖZDEMİR, Şükrü DURSUN

Selcuk University, Department of Environmental Engineering 42031, Konya-TURKEY

Accepted 13 October 2006

Abstract

Air pollution comes from low quality fossil fuels usage and/or used unsuitable technologies for production of energy. On the other hand, the natural factors such as temperature, atmospheric pressure, wind speed and directions, topographic structure, relative humidity, precipitation, and artificial factors such as disorder urbanisation and industrialisation, low quality fuels use, motor vehicle density, decreasing green area in city centres may effect air pollution. A computerised modelling method can be used for calculation of the air pollution dimensions. In this study, a computer programme was prepared for solution of the air pollution problems based on air pollution dispersion period and dispersion factors.

Designated pollutant factors in this modelling method are given below.

1. For dispersion period;

a) Uncontinuous source b) Continuous source

2. For pollutant type;

a) Point source b) Area source c) Line source

Modelling calculation and air pollution problems can be easily solved owing to prepared computer software based on above type of source, and calculation methods.

Keywords: Air pollution, Dispersion, Modelling, Pollution source type, Software.

Introductıon

The most important source group of air pollution are industrial furnaces and industrial process, traffic, small-scale businesses and domestic furnaces as well as special sources such as animal confinement systems, spray cans etc. A major proportion of the pollutants caused in these different areas has its origin in combustion processes, either in industrial and domestic furnaces or in traffic from combustion engines and air craft engines (Baumbach, 1996).

[#] *This study has been presented at "ESAEP, 13th Inter.l Symposium, October 8-12, 2005, Thessaloniki-Greece"*

[1] Corresponding author: *E-mail address*: eesmeray@selcuk.edu.tr, Tel.:+90 3322 2232080 Fax:+90 332 2410635

Urban and regional air pollution is today's greatest environmental threat for the most people. Industry, power generation and motor vehicles release pollutants that may lead to photochemical smog, haze and acidification. The nature of air pollution and the impact, it may have depended on a host of factors. These include the pollutant source, reactions in the atmosphere, transport by winds, and land features. Air pollution problems can often be minimised or even avoided completely. Scientists working on the pollution program with industry and the community to help achieve economic development without environmental harm (Vesilind *et al.,* 1994).

Versatile computer models assess the likely pathway that pollutants will take as they disperse through the atmosphere. The models incorporate the latest advances in air pollution science, gained through theoretical studies, laboratory experiments and field measurements (Anonim., 2005)

The protection of our environment is one of the major problems in the human life. The environment protection will become even more important in the next century. More important physical and chemical mechanisms are to be added to the models (as, for example, mechanisms for describing the production and transport of fine and ultra fine particles, mechanisms for describing better the natural emissions *etc*.). Moreover, new reliable and robust control strategies for keeping the pollution caused by harmful chemical compounds under certain safe levels have to be developed and used in a routine way (McRae *et al.*, 1984; Zlatev, 1995).

The large mathematical models, in which all physical and chemical processes are adequately described, can successfully be used to solve this task. The use of such models leads to the treatment of huge computational tasks. In a typical simulation several thousand time steps have to be carried out and at each time step systems of ordinary differential equations consist of up to several million equations have to be solved (Zlatev *et al.* 1992). The effective solution of such huge tasks requires combined research from specialists from the fields of environmental modelling, numerical analysis and scientific computing (Zlatev *et al.* 1993; Georgiev, 2000).

Material and Methods

Model Parameters Optimization

In this study, source categorization to number and spatial disruption includes single or point source (stationary), are or multiple sources (stationary or mobile), and line sources. Point sources characterize pollutant emissions from industrial process stacks and fuel combustion facility stacks. Area sources include vehicular traffic in a geographical area. Included in these categories are transportation sources, fuel combustion in stationary source, industrial process losses, solid waste disposal, and miscellaneous items. This organization of source categories is basic to the development of emission inventories. Line source include heavily travelled highway facilities and the leading edges of uncontrolled forest fires (Liu & Liptak, 2000).

After than this determinations, researched to about air quality dispersion modelling types. Air quality dispersion models are useful tools for determining concentration impacts from proposed as well as existing sources. The model can be categorized into four general classes: Gaussian, numerical, statistical (empirical), and physical. The first three models are computer based, with numerical and Gaussian models dominating the field (Marchuk, 1985).

Gaussian-based models generally require three types of input data; source emission data, receptor data and meteorological data, though the latter two can be assumed in some cases. Source emission data provide the characteristics of the pollutant released to atmosphere. Receptor data provide the location where a predicted concentration is desired. Meteorological data provide the conditions for the model determine how to emissions are transported from the source to the receptor (Liu & Liptak, 2000).

Computer Applications

This programming had written with Microsoft Visual Basic 6.0 programming language and Windows-Xp Operation system. System requires are Pentium II or above CPU, 128 Mb Ram and 5 Mb free disk space.

Hereafter, the Gaussian Dispersion Modelling would be used for air pollution problems solution. The Gaussian-based model is effective for representing the plume diffusion for a range of atmospheric conditions. The technique applies the standard deviation of the Gaussian distribution in two directions to represent the characteristics of plume downwind of its origin.

Equations given below and *etc*. were used for air pollution problems dissolve on basis Gaussian Dispersion Modelling:

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

was for plume contaminant concentration at a point in space,

$$C(x,y,0)=\frac{Q}{\pi u\sigma_y\sigma_z}e^{-\frac{y^2}{2\sigma_y^2}}e^{-\frac{H^2}{2\sigma_z^2}} \quad (2)$$

was for plume contaminant concentration at ground level,

$$C(x,0,0)=\frac{Q}{\pi u\sigma_y\sigma_z}e^{-\frac{H^2}{2\sigma_z^2}} \quad (3)$$

was for contaminant concentration at ground level along the plume centreline

$$C(x,0,0)=\frac{Q}{\pi u\sigma_y\sigma_z} \quad (4)$$

was for contaminant concentration at ground level along the plume centreline when the emission source is at ground level, and different equation for different conditions were used.

Where the symbols were used in the above equation:

C_x = the downwind concentration at a point x,y,z ($\mu g\ m^{-3}$),

Q = the emission rate of pollutants ($g\ s^{-}$),

σ_y, σ_z = the plume standard deviations (m),

u = the mean vertical wind speed across the plume height ($m\ s^{-}$),

y = the lateral distance (m),

z = the vertical distance (m),

H = the effective stack height (m),

Above equations were produced from the mathematical methods of Eulerian and Lagrangian models which were originated from the Gaussian Dispersion Model (Vesilind, *et al.* 1994). Production of these models takes several stages and after these stages, program might be used.

Programs main menu is shown in Figure 1. Firstly two emission types according to time and three different pollution types might be selected form the main menu. After then, required data would be input into correct places. Pressing to the calculate button, results would be obtained on the screen. When user need to graphical view to deal with calculated results, user can obtain by pressing to the graphical view button.

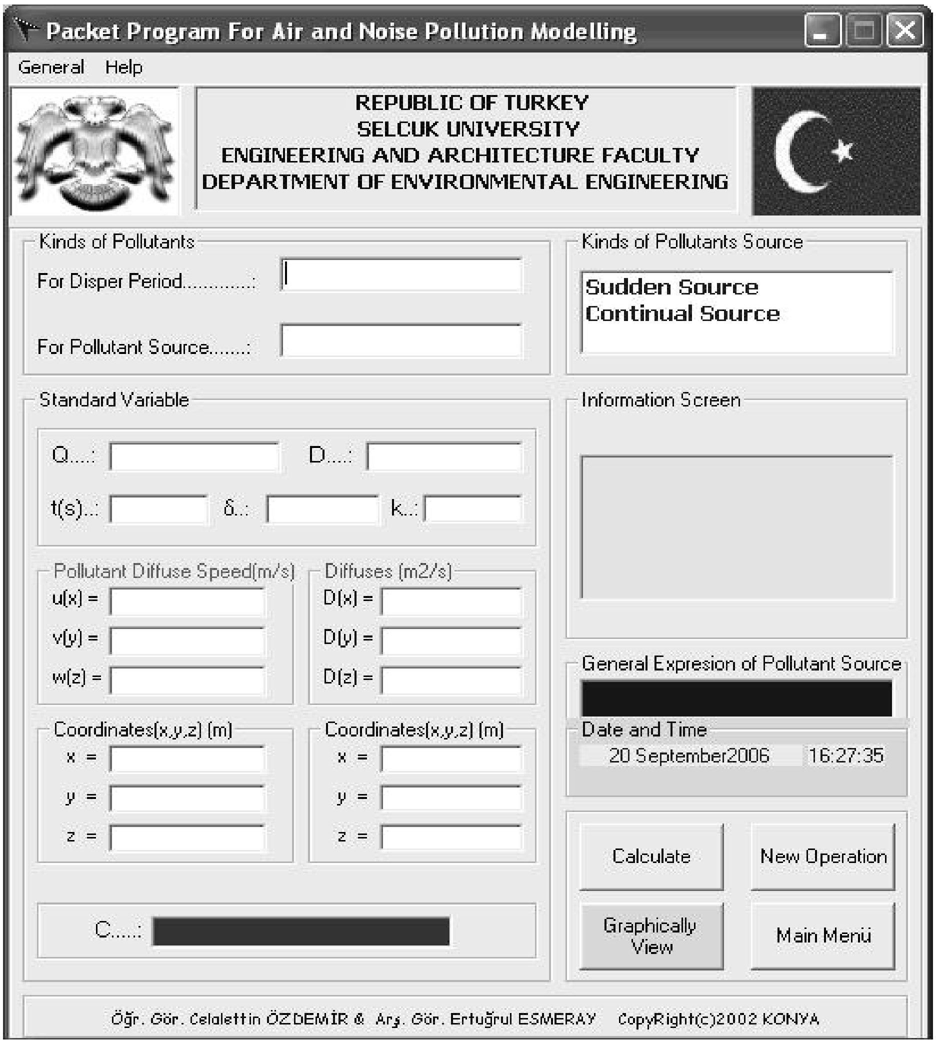

Figure 1. Program's interface

Programs graphical data and projection interface is shown in Figure 2

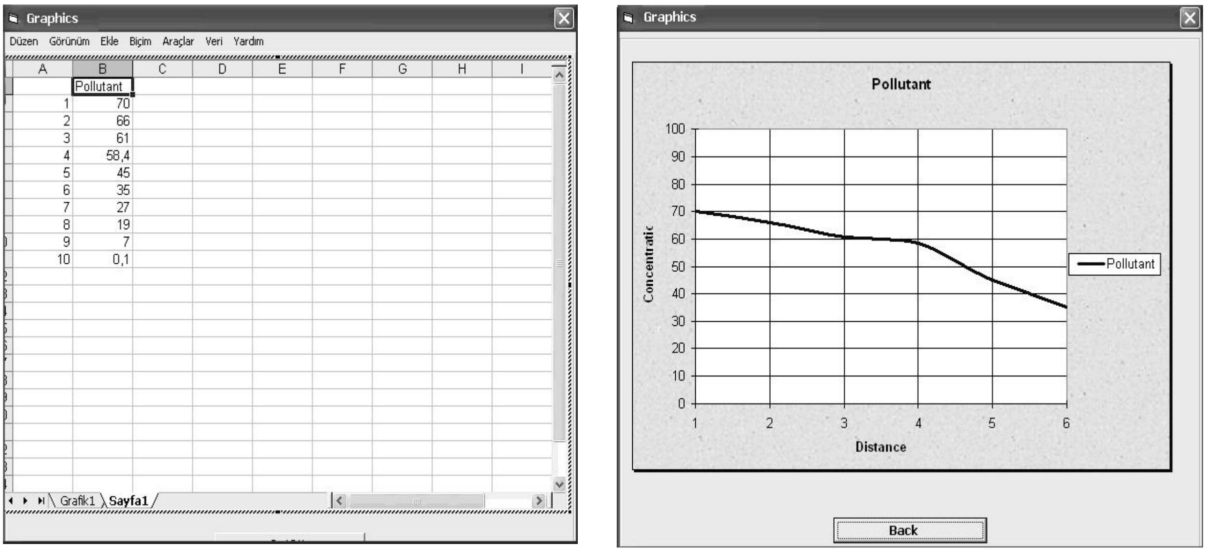

Figure 2. Program’s graphical data and projection interface

Results and Discussion

Some main equations and some other derived equation were used for the programme prepared in this study. Main source was Gaussian Plume models for the analysing the air pollution dispersion from the important pollutant source to the environment.Using this programme, dispersion period and pollutant type were selected from program main input field according to investigation area problems. Some parameters as like the downwind concentration at a point x,y,z, ($\mu g/m^3$), the emission rate of pollutants, (g/s), the plume standard deviations, (m), the mean vertical wind speed across the plume height, *etc*. were input in the suitable data field. Then results were calculated automatically via pressing to the “calculate button”. Graphical views can be also seen in the graphical projection part.

Results obtained from this programme were less standard deviation and quite convenient for the calculation of air pollution, and also very fast solution for the problems. When this programme is, compared with others which are ISC3, CTDMPLUS, BLP, OCD, CMAQ, REMSAD etc. (EPA, 2001), keeps very low disk space and also dose not needs large free disk space. In the other modelling programme needs special data file to use in the programme, but this recent programme, all data may input manually at the given units, directly on the main menu. Processes steps and processes time are very short than the others and required results might be seen before he graphical mode.

References

Anonim. (2005) Csrio Atmospheric Research Web Site, Air Pollution,

Baumbach, G.,(1996) Air Quality Control, Springer- Verlag Berlin Heidelberg, , ISBN:3-540-57992-3,Newyork, 1996

Georgiev K.T., (2000) Two dimensional computer modelling of long range transport of air pollutants, Journal of International Research of Publication, Issue 1/ 2000/01, ISBN: 1311-8978

H.F.Liu, D., Liptak G.,B.,(2000) Air Pollution, ISBN: 1-56670-513-42000, Lewis Publishers, Newyork

Marchuk, G., (1985) Mathematical modelling for the problem of environment, Studies in Mathematics and Applications, 16, North-Holland, Amsterdam

McRae, C., Goodin, W., Seinfeld, J. (1984) Numerical solution of the atmospheric diffusion equations for chemically reacting flows, J. of computational Physics, **45**,1-42

Seinfeld, J., (1986) Air Pollution, Wiley, New York

U.S. Environmental Protection Agency, (2001) Appendix W to part Guideline on Air Quality Models, 40 CFR Part 51, Chapter 1, Title 40, (Protection of Environment) of the Code of Federal Regulations, Research Triangle Park, NC, USA.

Vesilind, P.A., Peirce, J.J. and Weiner, R. F., (1994) Environmental Engineering, Butterworth Heinemann. 3rd Ed.

Zlatev, Z., (1995) Computer treatment of large air pollution models, Kluwer Academic Publ., Dordrecht-Boston-London

Zlatev, Z., Christensen, J., Eliassen, A., (1993) Studying high ozone concentrations by using the Danish Eulerian model, Atmospheric Environment, **27A**, 845-865

Zlatev, Z., Christensen, J., Hov, O., (1992) An Eulerian air pollution model for Europe with nonlinear chemistry, J. of Atmospheric Chemistry, **15,**1-37