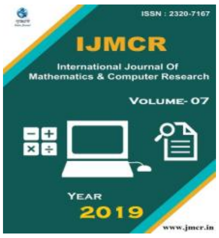
International Journal of Mathematics and Computer Research
ISSN: 2320-7167

Volume 07 Issue 09- September 2019, Page no. - 1997-1999
Index Copernicus ICV: 57.55
DOI: 10.33826/ijmcr/v7i9.01



Mathematical Model for Air Poisoning Due to Spray of Pesticide on Crop in Field

Dr. Avhale. P.S

Department of Mathematics, Shivaji Arts and Science College Kannad Dist. Aurangabad (M.H), India

ARTICLE INFO

Corresponding Author:
Dr. Avhale P.S.

ABSTRACT

Day to day resistance power of insecticide increase due to which they are unaffected by pesticide so farmer prefer more hazards pesticide spray on crop, due to which many diseases appear in animal and human. Different pesticide spray affects the different organs in living animal. Slowly it also disturbs the life biodiversity. More concentration of pesticide is dangerous to living animal and human. So it is necessary to define safe distance from spread field. It is also necessary to mention the time limitation to avoid the entry of living beings in the field by seller on the product. So we try to develop the mathematical model for source as point source and line source is a farming field and try to solve the model.

KEYWORDS: Solution of advection diffusion equation, dispersion.

Subject classification (AMS) : 35XX-35K xx , 76XX-76Rxx, 76XX-7605, 76XX-76Zxx-76Z05 and 92XX-92B

Introduction

The problem like the air pollution in cities, also in rural area, spray on crop of hazardous pesticide has become so severe that there is a need for timely information about changes in the concentration level. The air poisoning i.e. dispersion is a complex problem. It covers the contamination transport and diffusion in the atmosphere. The poisoning dispersion in the atmosphere depends on chemical features, meteorological, emission and terrain conditions. Physical and mathematical models are developed to describe the air poisoning due to dispersion of pesticide Physical models are small scale representations of the atmospheric flow carried out in wind tunnels. Mathematical models are divided in to statistical and deterministic models. Statistical models are based on analysis of past monitoring air quality data. Deterministic models are based on a mathematical description of physical and chemical processes taking place in the atmosphere. These models are based on mathematical equations, express conservation laws of mass, momentum and energy. The deterministic models are divided in to Eulerian, Lagrangian and Gaussian models.

Gaussian diffusion models are extensively used in assessing the impacts of existing and proposed sources of air pollution on local and urban air quality, particularly for regulatory applications. The history of Gaussian diffusion modeling goes back to the early 1920s when foundations of gradient transport and statistical theories of diffusion were laid. Earlier, temperature distributions in certain heat conduction problems were shown to be Gaussian, as were the concentration distributions in problems of molecular (Brownian) diffusion. In his classical paper on scattering of smoke in a turbulent atmosphere, Roberts (1923) obtained the solutions to the mean diffusion equation with constant-eddy diffusivities for different source configurations. His solutions showed Gaussian distributions in ensemble-averaged smoke puffs from an instantaneous point source. Gaussian concentration distributions were also derived in plumes from continuous point and line sources under certain simplifying assumptions (equivalent to the slender-plume approximation). Although Roberts (1923) did not put his solutions in the standard Gaussian forms, using σ_x, σ_y, and so on, he provided the original theoretical basis for what came to be known as Gaussian diffusion models. A stronger theoretical basis, without recourse to the questionable gradient transport hypothesis, was later provided by the statistical theories and random-walk models of particle dispersion in homogeneous turbulent flows.

Theoretical basis for Gaussian diffusion models is limited to idealized uniform flows with homogeneous turbulence. For continuous point and line sources, mean wind speed is also required to be larger than the standard deviations of turbulent velocity fluctuations, so that the upstream or longitudinal diffusion can be neglected. Mean winds and turbulence encountered in the atmosphere, particularly in the

PBL, rarely satisfy the above simplifying assumptions of the theory. Frequently, one encounters significant wind shears, in-homogeneities of turbulence, and weak winds to make the theoretical basis of Gaussian diffusion modeling somewhat tenuous, if not totally invalid.

Gaussian plume model uses a realistic description of dispersion, where it represents an analytical solution to the diffusion equation for idealized circumstances. The model assumes that the atmospheric turbulence is both stationary and homogeneous. In reality, none of these conditions is fully satisfied. Attention of researchers has been attracted by dispersion of air contamination in many ways .Air quality mathematical model is developed by considering the rate of change of pollutant concentration in terms of average wind and turbulent diffusion which is derived from the mass conservation principle

$$\frac{\partial C}{\partial t}+\left(u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}+w\frac{\partial C}{\partial z}\right)=\frac{\partial}{\partial x}K_x\frac{\partial C}{\partial x}+\frac{\partial}{\partial y}K_y\frac{\partial C}{\partial y}+\frac{\partial}{\partial z}K_z\frac{\partial C}{\partial z}+Q+R------(1)$$

Where C= pollutant concentration; t = time; u, v, w = wind speed co-ordinate in x, y and z direction; K_x, K_y and K_z = coefficient of turbulent diffusion in x, y and z direction; Q = Source; R = sink

Many assumptions and approximations are implied in the Gaussian plume model. Some of the important assumptions are (Lyons and Scott, 1990):

1. Continuous emission from the source at a constant rate, at least for a time equal to or greater than the time of travel to the location (receptor) of interest. The plume diffusion formulae assume that release and sampling times are long compared with the travel time to receptor, so that the material is spread out in the form of a steady plume between the source and the farthest receptor. A shorter release will result in an elongated puff with a time-dependent concentration field.

2. Steady-state flow and constant meteorological conditions, at least over the time of transport (travel) from the source to the farthest receptor. This assumption may not be valid during rapidly changing meteorological conditions, such as during the passage of a front or a storm and also during the morning and evening transition periods.

3. Conservation of mass in the plume. The continuity equation satisfied by the Gaussian plume formula is a mathematical expression of the condition that the mass flow rate through any plume cross section is equal to the source emission rate. This implies that none of the material is removed through chemical reaction, gravitational settling, or deposition at the surface. All the material reaching the surface through turbulent diffusion is reflected back and none is absorbed there.

4. Gaussian or reflected Gaussian distribution of mean concentration in the lateral (cross-wind) and vertical directions at any downwind location in the plume. The assumption of Gaussian distribution in the vertical direction is somewhat questionable, but does not appear to affect adversely the model predicted ground-level concentrations.

5. A constant mean transport wind in the horizontal (x-y) plane. This implies horizontal homogeneity of flow and the underlying surface and becomes invalid over a complex terrain.

6. The variation of wind speed with height can also be considered in more accurately estimating the effective transport velocity, but this requires the knowledge of vertical concentration distribution in the plume at each receptor location. The variation of wind direction with height is ignored, although its effect on the lateral plume spread and concentration field can be considered superficially through an appropriate parameterization of σ_y

7. Strong enough winds to make turbulent diffusion in the direction of flow negligible in comparison with mean transport. This assumption, also known as the slender-plume approximation, which is implicit in the Gaussian plume model, generally becomes invalid very close to the source where material diffuses up-wind of the source due to longitudinal velocity fluctuations. The assumption becomes invalid farther and farther away from the source as mean wind becomes weaker and vanishes entirely (e.g., under extremely stable and free convection conditions).

In steady state above equation is reduced to model explained in abstract

$$u\frac{\partial C}{\partial x} - w_{set}\frac{\partial C}{\partial z} = \frac{\partial}{\partial x}K_x\frac{\partial C}{\partial x} + \frac{\partial}{\partial z}K_z\frac{\partial C}{\partial z} + Q\delta(x)\delta(y)\delta(z) \\ - - - - - - - - (2)$$

With boundary condition

Boundary conditions $K_z\frac{\partial C}{\partial z} + W_{set}C = W_{dep}C$ at

$z = 0(deposition)$

$C \to 0$ as $x, y \to \infty$ and $z \to \infty$

Particles settle due to gravity at speed W_{set} (m/s). Deposition occurs at the ground at speed W_{dep} (m/s).

Gaussian plume solution to this problem is given by

$$C(x,y,z) = \frac{Q}{2\pi U\sigma_y\sigma_z} exp\left(-\frac{y^2}{2\sigma_y^2}\right) \exp\left(-\frac{z^2}{2\sigma_z^2}\right) - - - - (3)$$

Where U is constant the wind velocity. σ_y and σ_z are the parameters of the normal distribution in y and z directions.

Where cross wind dispersion factor is

$$F_y = \frac{1}{\sqrt{2\pi\sigma_y}} \exp\left[-\frac{y^2}{2\sigma_y^2}\right] - - - - - - - - - - - - (4)$$

Which indicates that along the y-axis, concentration is normally distributed, with the maximum value at the plume centerline which is inversely proportion lateral dispersion pararmeter.

Vertical dispersion factor

$$F_z = \frac{1}{\sqrt{2\pi\sigma_z}} exp\left[-\frac{z^2}{2\sigma_y^2}\right] - - - - - - - - - - - - (6)$$

Line source models

A line source can be considered as a superposition of point sources. The solution for finite

line source can be obtained by integrating point source solution from $y_s = y_1$ to y_2 with unit

source strength Q_i□ with the same n γ 's as in point source in different boundary conditions

$$C(x,y,z) = \int_{y_1}^{y_2} C(x, y_s, z)$$

Conclusion

High concentration of pesticide is harmful to health of living animal. We tried to write expression for concentration using advection diffusion equation as solution of this equation by using Gaussian plume formula.

References

1. Prashant Chandra1, Jaipal 1, V.K.Katiyar *Mathematical model for dispersion of air pollutant considering settling of particles and dry deposition* Int. J. of Mathematical Sciences and Applications, Vol. 1, No. 3, September 2011, 1591-1595.
2. Marie Emmanuel Ntigura Habingabwa, Fidèle Ndahay and Fredrik Berntsson *Air Pollution Tracking using PDEs* Rwanda Journal,: Mathematical Sciences, Engineering and Technology Volume 27 Series C, 2012, 63-69
3. Oliver Maruntalu, Gheorghe Lazaroiu,Dana Andreya Bondrea *Mathematical model for air pollutants dispersion emitted by fuel combustion* U.P.B. Sci. Bull., Series D, Vol. 77, Iss. 4, 2015, ISSN 1454-2358.
4. Adel A. Abdel-Rahman *On the atmospheric dispersion and gaussian plume model* 2nd International Conference on waste management, water pollution, air pollution, indoor climate (WWAI'08) Corfu, Greece, October 26-28, 2008
5. *Marek Slesicki Application of mathematical modelling methods in the protection of groundwater environment* Journal of water and land development J. Water Land Dev. No. 13b, 2009: 31–3