Curriculum Vitae

A) PERSONAL PARTICULARS

Discipline **Post**	**Department of energy and environment/ Air Pollution** **Professor**
Full Name	Dr Uma Arora
Date of Birth (dd/mm/yyyy)	17/06/1962
Nationality	Indian
Gender (Male/Female)	Female
Present Address	House No.631, Sector 9, Faridabad, 121006, Haryana
Email addresses	umarora15@gmail.com; umarora15@hotmail.com
Mobile Numbers	+91 8368270039 , +91 818114885
Research and Teaching	**Research**: Modeling of Atmospheric Pollution Problems and analysis of real time pollution data. **Research Plan for Future**: Modelling and solution of atmospheric, implementation of a model for removal of air pollution and environmental problems and Modeling and study of the effect of EMR emitted from Mobile Phone and from mobile tower on Human Organs viz. head, eye and trunk and Modeling of various type of atmospheric pollutions and their effect on human health.

B) DETAILS OF EDUCATION

Degree/ Certificate	Year of completion	Board/University & Location	% of marks/ Division	Main Subjects	Remarks
PhD	1992	Department of Mathematics, University of Roorkee, Now IITR, Uttarakhand	A Grade, obtained very good remarks from the Examiners.	Mathematics, Title of PhD thesis: "Mathematical modelling and Numerical solution of Atmospheric Pollution Problems".	Fellowships: CSIR (SRF) and UGC (SRF and JRF). Papers Published in Journals and papers presented in conferences based on the work done during PhD.
M Phil	1985	Department of Mathematics, University of Roorkee, Now IITR, Uttarakhand	64.1/II	Mathematics: Numerical Analysis, FORTRAN. Dissertation: Mathematics: Title of dissertation "Numerical solution of steady	Published a research paper based research work of dissertation.

				motion of second-order fluid past a circular cylinder with suction or Injection",	
M Sc	1984	Govt. Raza Post Graduate college, Rampur, Rohilkhand University, Bareilly, UP, India.	70 / I	Numerical Analysis, Statistics, Complex Analysis, Analysis etc.	Distinction in 5 papers**.**
A Certificate Course	2017	XLRI Jamshedpur, Jharkhand India	Successfully Completed in June 2017	"Leadership and Change Management"	Live course on Internet
B.Sc	1981	Govt. Raza Post Graduate College, Rampur, Rohilkhand University, Bareilly, UP, India.	59.2 / II	Mathematics, Physics, Chemistry.	
12th	1979	Govt. Khursheed Girls Inter College, Rampur, U.P. Board, Allahabad, India.	60.6 / I	Mathematics, Physics, Chemistry, English, Hindi.	Merit Scholarship 1977 -79
10th	1977	Govt. High School, Dakpathar, Dehradun, U.P. Board, Allahabad, India.	69 / I	Mathematics, Science, Biology, English, Hindi.	Distinction in 2 papers.
International General certificate of Secondary Education Training in School Based Assessment	2008	From Cambridge University at Lalaji Memorial Omega International School, Chennai, India.	Very Good remarks by The evaluator at University.	Obtained certificate for course work Assessment accreditation from Cambridge University by Submitting evaluation work on many projects.	Very Good remarks.
Certificate Online course	2007	From Cambridge University at Lalaji Memorial Omega International School, Chennai, India.	Successfully completed.	IGCSE Mathematics Online course	Successfully completed.

Latest Work Experience Adjunct faculty at J.C. Bose University of Science &Technology YMCA Faridabad July 2018-Dec 2019.

C) **WORK EXPERIENCE**

Period From – To	University/Institute	Position Held	Salary last Drawn	Description of my work/duties
11/08/2014-31/07/2016	JRE Group of	Professor		Taught B Tech Classes.

	Institutions, Greater Noida, Affiliated to Dr APJ Abdul Kalam Technical Univ. India.	and Exam cell coordinator.	₹ 109299/- per month Pay Scale: ₹ 37400-67000/- Basic Pay: ₹ 39,550/-	Subjects taught: Math III, II, I (Numerical Analysis, Statistics, Complex Analysis, Differential Calculus, Matrices, Vector Analysis) And Operations Research. The institute was having B. Tech Courses only. Worked As Exam Cell coordinator.
14/09/2010-29/11/2013	Sharda University, Greater Noida, UP,India.	Professor and Coordinator.	₹1,03,868/- Per month. Pay Scale: ₹ 37400-67000/- Basic Pay: ₹ 56,642/-.	Taught PhD, M Tech, B Tech, MCA, BCA classes and Research students. **Subjects taught**: Numerical Analysis (NA), Matrices, Differential Equations, Core Maths to B Tech, Operations Research to M Tech Classes, NA, FEM to PhD students, NA to MCA and Linear Algebra to BCA students. Worked as Interdepartmental coordinator. Member of Departmental Research Committee, Academic Council, Board of studies, Syllabus Preparation Committee, Flying squad. Paper setter. **Prepared Syllabuses** for B Tech, M Tech, MCA, BCA and MS and BS.
29/12/2008-13/09/2010	Galgotias College of Engineering and Technology, Greater Noida Affiliated to Dr APJ Abdul Kalam Technical University, Lucknow, UP, India.	Professor and Head and Coordinator.	Approx. ₹ 55000/- Per month. Pay Scale: ₹16400-22,000/-.	**Subjects taught**: Maths III:(Numerical Analysis, Statistics, Complex variable) to B Tech, Operations Research to M Tech, Statistics to MBA, Numerical Analysis to MCA classes. Administrative work as Head of the department, Interdepartmental coordination.
01/05/2007-08/09/2008	Lalaji MemorialOmega International school, Chennai, India.	Principal of IGCSE Stream and Head of Maths department.	₹ 24000/- per month+ medical.	Administrative work and Teaching. Obtained Course accreditation Certificate and Online training on Maths from Cambridge University.
14/05/2003-26/04/2007	Jaypee Institute of Information Technology University, Noida, UP, India.	Assistant Professor.	₹ 50,000/- per Month + LTC +Medical, Basic pay: ₹ 21000/-.	Taught to B Tech classes and Research work, Courses taught: B. Tech Projects.
8/10/2001-07/05/2003	College of Engineering Roorkee, Roorkee, UK, India.	Lecturer.	₹ 11000/-per month Pay Scale: ₹ 8000-13500/-.	Taught B Tech and MCA classes, Subjects taught: Graph Theory, Numerical Analysis, Core Maths to B Tech Classes.

11/02/1997-10/02/2001	CAS, IIT Delhi, India.	Research Scientist and Pool Officer.	₹ 13000/- per month+ accommodation +allowances + medical.	Research work, project in Charge. Worked on three research projects.
01/01/1996-30/06/1996	Department of Metallurgical Engineering, U.O.R., Roorkee.	Fellow-A	₹ 3600/- per month+ accommodation+ medical.	Worked on a research project.
05/01/1995-30/09/1995	IMS, Ghaziabad, UP, India.	Lecturer.	₹ 6000/ - per Month Pay scale: ₹ 2200-4000/- Basic ₹ 2425/-.	Taught MBA and MCA classes. Subjects taught: Operations Research and Graph Theory.
24/02/1993-24/01/1995	DST, Young Scientist Scheme Department of Mathematics, University of Roorkee, Now IIT Roorkee, UK, India.	Principal Investigator and Research Scientist.	₹ 4500/- per month Pay scale: ₹ 2275-4000/-, accommodation+ medical. Basic: ₹ 2275/-	Research work and Teaching to B Tech and M.Sc classes. Successfully completed a project under Young Scientist scheme of DST, Govt. of India. Subjects taught: Numerical Analysis, Matrices and Tutorials.
17/10/1986-01/04/1993	Department of Mathematics, University of Roorkee, Now IIT Roorkee, UK, India. .	SRF and JRF.	₹ 2100/- and ₹ 1800/- per month+ accommodation + Medical.	Research and Teaching to B Tech. Students. Obtained Ph D degree on "Mathematical modelling and Numerical solution of atmospheric Pollution Problems". Time dependent air pollution mathematical models were developed and solved. Numerical methods and FORTRAN were used as a tool to 'solve the models.
30/10/1985-16/10/1986	Department of Earthquake Engineering, University of Roorkee, Now IIT Roorkee, UK, India.	Research Assistant.	₹ 900/- per month,+ accommodation + medical.	Worked on a research project. Project was to make a structural design of 500 MW by using Finite element method.

D) PROFESSIONAL TRAINING

S. No.	Organization	Period		Details of Training
		From	To	
1.	University of Roorkee, Roorkee, Now Indian institute of Technology, Roorkee, UK, India.	07/08/1985	14/08/1985	Elementary course on "Vedic Mathematics". Learnt formula and their application in Arithmetic.
2.	University of Roorkee, Roorkee, Now Indian institute of Technology, Roorkee, UK, India.	07/08/1987	17/08/1987	Workshop on "Vedic Mathematics and its computational potentialities" Application of Vedic Mathematics to higher Level mathematical problems.
3.	Centre for atmospheric Sciences (CAS), IIT Delhi, India.	07/12/ 1992	24/12/ 1992	Winter School on "Understanding The Present climate and its future change over the Indian sub-continent due to global warming".
4.	CAS, IIT Delhi, India.	10/11/ 1997	21/11/ 1997	Training on "Modelling and Monitoring of costal Marine processes (MAMCOMP)".
5.	CAS, IIT Delhi, India.	14/12/1998	09/01/1999	A part time course on "C and C++ Object Oriented Programming".
6.	JIIT, Noida, Workshop, held at Solan, Shimla, India.	May 2004	May 2004	Faculty development program
7.	Cambridge University at Lalaji Memorial Omega International School, Chennai.	Dec. 2007	Dec. 2007	Obtained online Training Certificate of IGCSE Mathematics from Cambridge University.
8.	Cambridge University at Lalaji Memorial Omega International School, Chennai.	June 2008	August 2008	Successfully Completed Course work accreditation for IGCSE from Cambridge Univ.
9.	Jaypee Institute of Information Technology, Noida, UP, India.	20.04.2011	20.04.2011	Attended a workshop on "Wavelets and its Application in Signal Processing "

M. Sc Projects:

(i) "Analysis of real time concentrations of vehicular carbon monoxide near outer ring road (Delhi)" co-guide Prof. G. Jayaraman.

(ii) "A case study of vehicular pollutants using various meteorological variables" co-guide Prof. G. Jayaraman.

Brief Profile:

I am having teaching and research experience in reputed institutes like IIT Roorkee, IIT Delhi, Sharda University, Galgotias College of Engineering and Technology, Greater Noida Jaypee Institute of Technology, Noida, etc. and I have worked in various capacities.

I taught at **IIT Roorkee for more than 7 years during my PhD tenure and Project work.**. I taught B. Tech and MSc Classes at IIT Roorkee. I taught PhD, M Tech, B Tech, MCA and BCA classes and guided M Sc and B Tech projects during my teaching tenure**.**

I pursued Post doctorate research work for **4 years at IIT Delhi as Pool Officer and Research Scientist at Centre for Atmospheric Sciences, IIT Delhi**. I **successfully completed Young Scientist Project at Department of Mathematics, University of Roorkee** as Principal Investigator **sponsored by DST**, Govt. of India. **I have published papers in International and national journals and presented papers in international and national conferences.**

I have worked as **Head of the Department at Engineering College level and Coordinator of the department at University level**. I worked in various committees viz. **Board of studies, Academic Council, Syllabus committee, various interview committees and Flying Squad at University Level**.

I have prepared syllabuses for B Tech, M Tech, BS, MS, MCA and BCA and question papers and many other works for UPPCS and various Universities. I did **evaluation work for Joint Entrance examination (JEE), Roorkee Entrance Examination (REE).**

I have also done an online live course "**Leadership and Change Management**" from XLRI, Jamshedpur.

I have also worked as a **Principal of IGCSE stream in LMOIS, an International School affiliated to Cambridge University.** I have successfully completed **course accreditation and online training of Mathematics from Cambridge University.**

E) PUBLICATIONS / CONFERENCES

International Journal:

'Removal model suitable for air pollutants emitted from an elevated source' by Uma Arora, Sunita Gakkhar, R.S. Gupta, Applied Mathematical Modelling, Journal Elsevier V.15, pp. 386-389, 1991.
ISSN: 0307-904X
URL: http://www.sciencedirect.com/science/article/pii/0307904X9190065W

Numerical Solution of Advection-diffusion problems by using parallel Computing by Uma Arora International Journal of Recent Trends in Engineering & Research (IJRTER) Volume 02, Issue 9; pp:231--238, September-2016[ISSN: 2455-1457] :
URL: http://www.ijrter.com/issue-papers/?select_volume=2&select_issue=9

Analysis of vehicular Nitrogen Oxides and meteorological variables in New Delhi by Uma Arora, International Journal of Research in Engineering and Applied Sciences (IJREAS) Vol. 6 Issue 10, October - 2016, pp. 41-56 ISSN(O): 2249-3905, ISSN(P): 2349-6525 Scopus Id : 9FC448C8A653C9AF Thomson Reuters ID:L-5236-2015, URL:http://euroasiapub.org/wp-content/uploads/2016/11/5EASOct-4083....-1.pdf

Statistical analysis of vehicular carbon monoxide and meteorological variables in New Delhi by Uma Arora International Journal of Recent Trends in Engineering & Research (IJRTER) Volume 02, Issue 09; pp.213-222 September-2016[ISSN:2455-1457],
URL: http://www.ijrter.com/issue- papers/ volume=2

Modelling and numerical solution for primary and secondary pollutant with different sources, U Arora Matem. Mod., Russian Journal 2003, Volume 15, Number 7, 55–63, Russian mathematical portal Math-Net.Ru.
URL: ttp://www.mathnet.ru/php/archive.phtml?wshow=paper&jrnid=mm&paperid=421&option_lang =eng

Mathematical models for removal of particulate pollutant in presence of plant canopies, U Arora Matem. Mod., Russian Journal 2003, Volume 15, Number 5, 54–60, Russian mathematical portal Math-Net.Ru.
URL: ttp://www.mathnet.ru/php/archive.phtml?wshow=paper&jrnid=mm&paperid=459&option_lang *=eng*

Model for settling and deposition of particulates emitted from an elevated source, U Arora Matematicheskoe Modelirovanie (Matem. Mod., Russian Journal 2003, Volume 15, Number 3, 122–128, Russian mathematical portal Math-Net.Ru.

URL:
http://www.mathnet.ru/php/archive.phtml?wshow=paper&jrnid=mm&paperid=485&option_lang =eng

National Journal:

'Numerical solution of steady motion of a second order fluid past a porous circular cylinder', by H.G. Sharma, Manoj Kumar and Uma Arora in Indian Journal of Technology, V.24, pp.783-786,1986.

International Conference:

'Mathematical model to study the effect of non-ionizing EM radiation of mobile phone on human head in presence of cell tower radiation', 6th China India Japan Korea Mathematical Biology Colloquium Cum Conference (CIJKMBCC) under the Aegis of IAMMS, IIT, Kanpur, August 23-26, 2017.

Role of Plant Canopies in the Removal of particulate pollutant' by Uma Arora presented in an International conference INTROMET held in Dec 2-5, 1997 at CAS, IIT Delhi.

'Mathematical model for automobile emitted pollutant gases' by Uma Arora, G. P. Singh, P.K. Choudhary and Malti Goel presented in an international conferenceINTROMET held in Dec.,2-5, 1997 at CAS. IIT Delhi.

'Numerical solution for air pollutant transport from an elevated source', by R.S. Gupta, Sunita Gakkhar and Uma Arora Proceedings of international conference on environmental planning and Management held at University of Roorkee, Roorkee Dec 5-7, 1990.

National Conference:

'Mathematical modelling of air pollution and wavelets' presented by Uma Arora at 11^{th} Biennial conference of Indian Society of Industrial and Applied Mathematics (ISIAM), December 15-16, 2012 at Gautam Buddha university (GBU), Greater Noida, India.

'Time dependent study of transport of pollutant through and around the plant canopy', by Uma Arora, Sunita Gakkhar and R.S. Gupta presented at G.B. Pant University of Agri. & Tech. Pantnagar in 37th congress of ISTAM, January,14-17, 1993.

Mathematical modelling and Numerical solution for primary and secondary pollutant', by Uma Arora, Sunita Gakkhar and R.S. Gupta presented in National Seminar on Mathematical Modelling at Jadavpur University, March 7-8, 1994.

'Study of delayed removal, gravitational settling and deposition of air pollutants' by Neelam Raheja, Uma Arora & Sunita Gakkhar presented in the IX ISME conference on Mechanical Engg. November, 10-11, 1994 at University of Roorkee.

F) Research Projects completed: I have worked on the following projects:

S. No.	Title of the Project	Sponsored by	Position hold	Completed/ Under Progress	Duration
1	'Mathematical Modelling and Numerical Solution of Atmospheric removal processes'.	Sponsored by DST, under young scientist scheme, carried out at University of Roorkee, Roorkee, now known as IITR.	PI, Research Scientist.	Completed	Feb 1993 - Jan 1995 2 years.
2	'Mathematical modelling of accidental release'.	Sponsored by CSIR carried out at CAS, IIT Delhi.	Pool Officer, Research Scientist.	Completed	Feb 1997 - Feb 2000 3 years.
3	'Real time measurements of NO_2 emission from vehicular traffic and impact assessment studies on urban atmosphere with special reference to health'.	DST and Japan cooperation Agency.	Project –in-charge PI was Ex - Prof S.K. Dube, CAS, IITD, Dr (Mrs.) Malti Goel, DST, Co-PI Prof G. Jayaraman, CAS, IITD.	Completed	Feb 1997- Aug1998.
4.	Wave Prediction Modelling for Indian Seas Using IRS-P4, Data: IITD –SAC joint project.	World bank, DRDO.	Project Scientist. Dr S.K. Dube was PI.	Completed.	Feb 2000- Feb 2001.

Dr Uma Arora
Faridabad

Removal model suitable for air pollutants emitted from an elevated source

Uma Arora, Sunita Gakkhar, and R. S. Gupta

Department of Mathematics, U.O.R. Roorkee, India

A time-dependent removal model for air pollutants from an elevated source is presented. The model considers the first-order (delayed) removal. The deposition of pollutants is accounted for by applying the absorptive boundary on the ground surface. The transport equation representing instantaneous and delayed removal is solved numerically by the fractional step method. A Lagrangian (moving cell) frame is used to solve the advection step, while a Eulerian (multibox) frame is applied to the diffusion and removal processes. Variable wind velocity and coefficient of diffusivity are considered. Velocity profile is approximated by a step function, which provides compatibility with the Eulerian grid spacing. Variable vertical grid spacing is considered to get good resolution concentration profile near the source.

Keywords: removal, ground deposition, advection, diffusion, variable wind velocity, fractional step method

Introduction

Pollutant concentration in the atmosphere is generally influenced by several processes such as advection, turbulent diffusion, deposition, removal, and conversion of gaseous pollutants to particulate materials. Pollutants may be removed from the atmosphere by natural cleansing processes, e.g., washout, rainout, and gravitational settling. The following equation,

$$\frac{\partial c}{\partial t} + \frac{\partial (uc)}{\partial x} + \frac{\partial (vc)}{\partial y} + \frac{\partial (wc)}{\partial z} = \frac{\partial}{\partial x}\left(k_x \frac{\partial c}{\partial x}\right) + \frac{\partial}{\partial y}\left(k_y \frac{\partial c}{\partial y}\right) + \frac{\partial}{\partial z}\left(k_z \frac{\partial c}{\partial z}\right) + R$$

describes the dynamics of advecting diffusing and reacting pollutant.

The steady-state, three-dimensional solution of the above atmospheric diffusion equation with settling and first-order removal is presented by Peterson and Seinfeld[1] to predict the airborne concentration of gaseous and particulate pollutants. Conversion of primary gaseous pollutant to secondary particulate pollutant is also considered.[1] An approximate solution to the advection-diffusion equation is obtained by Carmichael et al.[2] using the LOD method. Alam and Seinfeld[3] have given an analytical solution for first-order transformation of sulfur dioxide to sulfate and their wet and dry deposition from an elevated point source. The reversible absorption of a pollutant from an area source in a stagnant fog layer has been discussed by Seinfeld et al.[4] Atmospheric transport diffusion equations are associated with primary and with secondary pollutant, which is converted chemically from the primary pollutant.[5] Shukla and Chauhan[6] have suggested an integro-partial differential equation to study the effect of instantaneous and delayed removal on dispersion of pollutants. Rainout, washout, and conversion of primary pollutant to secondary pollutant are some of the examples of delayed removal.

This paper presents a mathematical model to study a delayed removal process for air pollutants emitted from a line source with variable wind profile and coefficient of diffusion. It has been shown that removal processes (instantaneous or delayed) decrease the pollutant concentration at any given point in space and time. It confirms the results obtained by Shukla and Chauhan[6] that concentration of pollutant may be greater in the case of delayed removal than in the case of instantaneous removal. Further variable wind may have a dominating effect over that of removal and diffusion mechanisms, resulting in unsymmetric isolines about the centerline. The dry deposition on the ground surface is taken into account.

Mathematical model

It is assumed that convection dominates over horizontal diffusion and vertical diffusion dominates over convection. Then the transport equation incorporating such types of removals may be written as

$$\frac{\partial c}{\partial t} + u\left(\frac{\partial c}{\partial x}\right) = \frac{\partial}{\partial z}\left(k_z \frac{\partial c}{\partial z}\right) - k_0 c_r \qquad (1)$$

Address reprint requests to Dr. Arora at the Department of Mathematics, U.O.R. Roorkee, PIN 247667, U.P. India.

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МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ 2003г., том 15, номер 5, стр. 54-60

МАТЕМАТИЧЕСКИЕ МОДЕЛИ ДЛЯ УДАЛЕНИЯ ОТДЕЛЬНОГО ЗАГРЯЗНЕНИЯ В ПРИСУТСТВИИ РАСТИТЕЛЬНОГО ПОКРОВА

© *Ума Арора*

MATHEMATICAL MODELS FOR REMOVAL OF PARTICULATE POLLUTANT IN PRESENCE OF PLANT CANOPIES

Uma Arora

Centre of Atmosphere Sciences II Delhi, Hauz Khas, New Delhi

Mathematical models have been presented to study the effect of plant canopies in reducing the concentration of pollutants. Various physical processes namely advection, diffusion, settling, deposition and combined influence of sedimentation & impaction have been considered. An elevated cross wind continuous line source of pollutant is considered. The wind velocity & coefficient of diffusivity have been taken as function of z inside the canopy though they are constant around and above the canopy. In order to obtain numerical solution a mixed finite difference and finite difference schemes are used to study the transient and steady state models respectively. Lagrangian frame is used to solve the advection step, while Eulerian frame is applied to rest of the processes. The results confirm the first hand expectation numerically that presence of canopy may reduce pollution of concentration remarkably.

Introduction

The pole of plant canopies in the removal of pollutants is still very less understood in comparison to the dry and wet removals. In addition to source characteristic, atmospheric and terrain conditions etc. the complexities also arise due to the properties of different types of plants and shrubs. Various physical properties such as plant height, foliage density, width of its distance from the source play an imporrtant role in removal of pollutants. Mathematical models and their numerical solutions have been studied considering various physical processes viz. advection, diffusion, settling and deposition and combined influence of sedimentation & impaction processes of air pollutant emitted from an elevated crosswind continuous line source. The domain of reference is divided into four sub domains namely clear and canopy regions. The plant canopy region is further divided into crown and stem area.

Mathematical model

The mass conservation equations for pollutant concentration $c(x,y,z,t)$ in the clear and capony regions may be written as

$$\frac{\partial c}{\partial t}+u_x\frac{\partial c}{\partial x}-w_1\frac{\partial c}{\partial z}=\frac{\partial}{\partial z}\left(k_z\frac{\partial c}{\partial z}\right) \tag{1}$$

and

$$\frac{\partial c}{\partial t}+u_x\frac{\partial c}{\partial x}-w_1\frac{\partial c}{\partial z}=\frac{\partial}{\partial z}\left(k_z\frac{\partial c}{\partial z}\right)-\beta\left(u_x c\cos\theta+\left(w_c c_+ k_z\frac{\partial c}{\partial z}\right)\sin\theta\right) \tag{2}$$

respectively. Here, t is time, u_x being the wind velocity; k_z the coefficient of diffusivity and w_1 and w_s the settling velocity of particles in clear and canopy regions respectively, θ the angular

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STATISTICAL ANALYSIS OF VEHICULAR CARBON MONOXIDE AND METEOROLOGICAL VARIABLES IN NEW DELHI

UMA ARORA
Ex-Scientist of IIT Delhi, 3-A Mansarover Apartments Sector 61 Noida

Abstract: The statistical analysis has been done to study the general characteristics of real time concentration of vehicular carbon monoxide (CO) and its correlation with meteorological variables namely wind speed, temperature, humidity, and wind direction. The continuous hourly concentration of CO and meteorological variables were measured at Indian Institute of Technology, Delhi (IITD) during Jan.,1997- Aug.,1998. In order to depict the proportion of variance in CO concentration accounted for by the predictors i.e. time & meteorological variables in four seasons, regression analysis has been done using SYSTAT. Pearson correlation coefficient & coefficients of regression equation also have been calculated for all the four seasons considering one, two, three and four independent variables using SYSTAT. The conventional statistics student's t - test and f - test were used to know quantitatively the effect of seasons on the concentration of CO.

For 1997, it is observed that average of weekend concentration of CO was significantly higher during early morning to till late afternoon, though in the evening it is lower compared to the average of weekdays concentration which is contradictory to first hand expectation. In 1998 there is shift in period which may be due to lack of data in 1998. It has been observed that percentage of concentration is considerably high both in 1997 and 1998 in comparison to the prescribed limits by Government of India. The CO concentration is found inversely correlated with wind speed and temperature and positively correlated with humidity. It is found both positively as well as negatively correlated with wind direction. In all the four seasons independent variable wind speed is the most significant variable. It was also found that mean is significantly same in autumn & winter seasons and it is significantly different in summer & rainy and rainy & autumn seasons. The f - test confirms the above result.

Key word index: Vehicular pollution, Statistical analysis, wind speed, Temperature, Humidity.

I. INTRODUCTION

The pollution front of Delhi, India's capital, continues to worsen rapidly over time due to industry and vehicles. In just seven years from 1986 to 1993, the number of vehicles in India has shot up by 17 million. In Delhi, an estimated 2000 metric tons of pollutants (CPCB, 1995) are released into the atmosphere everyday, gaseous pollutants from vehicles dominating CO with an estimated emission level of 1,063 tpd, tops the list, followed by other pollutants. The present paper concentrates on vehicular pollutant CO at a point in the city i.e. IIT Delhi. Few similar studies are available in literature, which are as follows-

A statistical analysis of the (Cheng et.al., 1998) sampling results was conducted to obtain general characteristics of the roadside particulate and SO_2 pollution in Hong-Kong and to investigate the effects of traffic volume and meteorological factors on the pollution levels. Correlation study (Cardenas et al.,1998) between CO, NO_y , O_3 and non-methane hydrocarbons and their relationships with meteorology for the Norfolk coast, U.K. found that the concentrations of the chemical species were mostly a function of source characteristics with chemistry playing a minor role. Morel et. al., (1999) treated as air pollution a stochastic process and derived a probability distribution for air pollution concentration which was used to analyze the data from Santigo.

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Numerical Solution of Advection-diffusion problems by using parallel Computing

DR. UMA ARORA
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Abstract: Mathematical models of advection- diffusion of atmospheric pollutants have been solved by parallel programming and obtained results have been compared with the numerical results obtained from sequential programming of mathematical models [1]. In sequential programming, governing equations have been fractioned by fractional step method and results obtained from prior processes have been used as initial condition for next process, though they are happening simultaneously in the atmosphere. Error introduces due to time gap in run of the code of various processes. Therefore, numerical methods with very small time step are being used to solve these models. Due to small time step number of computations increases and as consequence error increases. Parallel programming computes all the concurrent procedures in parallel therefore it reduce the errors because there is no time difference between the run time of the code of two or more simultaneous processes.

In this paper parallel computing, steps have been considered based on physical processes. For parallel computing three systems with LAN card were used. C programs were run on Knoppix operating system using MPI routines and BCCD bootable Cluster CD and predicted results have been compared with results obtained by sequential programming. In sequential programming C code was run on gcc compiler running on Linux and FORTRAN 77 Programming was run on DOS. It was observed that CPU time was very less in parallel computing in comparison to sequential programming for achieving steady state.

In the first model, conversion of primary pollutants, emitted elevated crosswind source, from to secondary pollutants, advection-diffusion, settling and deposition of primary as well as secondary pollutants have been considered. No source was considered for secondary pollutants. In the second mathematical model advection - diffusion of atmospheric pollutants emitted from continuous crosswind elevated line source and their settling in the atmosphere and deposition on the ground has been calculated by using parallel computing It is a particular case of first model.. In addition to continuous crosswind line source two other types of time dependent crosswind elevated line sources i.e. instantaneous and periodic sources have also been considered.

Keywords: Parallel computing, Advection-diffusion equation, settling of pollutants, conversion of pollutants, Elevated cross-wind line continuous, instantaneous and step type, power law wind profile

I. INTRODUCTION

Many physical and chemical processes viz. advection, dispersion, diffusion, source height, duration of effluent, wind velocity and its direction, settling of pollutants, deposition, rain out, washout and conversion of gases in the atmosphere etc. occur in atmosphere and they affect the concentration of the pollutants in short and intermediate range of the atmosphere. Removal of pollutants may occur in various reasons and in various ways viz. dry, wet removal and removal by conversion of pollutants. Settling in atmosphere and deposition at ground surface are very natural phenomenon of dry removal. Gravitational settling velocity depends upon the type, size of particulate particles and roughness of terrain and meteorological conditions. Rainout and washout are the natural wet removal phenomena. These physical processes also get affected by atmospheric conditions i.e. stable, neutral and unstable.

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МОДЕЛЬ И ЧИСЛЕННОЕ РЕШЕНИЕ ДЛЯ ПЕРВИЧНОГО И ВТОРИЧНОГО ЗАГРЯЗНЕНИЯ С РАЗЛИЧНЫМИ ИСТОЧНИКАМИ

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MODELLING AND NUMERICAL SOLUTION FOR PRIMARY AND SECONDARY POLLUTANT WITH DIFFERENT SOURCES

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Simultaneous unsteady advection - diffusion equations have been solved numerically to predict the concentration of primary and secondary pollutant. Mathematical model has been solved considering elevated time dependent line sources for primary pollutant. Three types of sources have been taken (a) instantaneous (b) step type function and (c) cross wind continuous and it is assumed that some part of primary pollutant is converting into secondary pollutant continuously and there is no direct source of secondary pollutant. A mixed finite difference scheme has been used to solve the model. Numerical results have been presented in graphical form. It has been found that concentration is very high in the case of instantaneous source though its spread is very less in comparison to other two sources for both the pollutants. In step type function concentration diminishes very fast in comparison to continuous source. It has also been observed that effect of power law profile of wind tilts the spread of concentration upwards.

INTRODUCTION

Conversion of one pollutant to other is a very natural and common phenomenon in the atmosphere. There are various pollutants which may fall under this category. Few cases from literature are as follows-

Jaunge [1] shows that the life time of SO_2 in the atmosphere could vary from one hour to as much as few weeks depending on which reactions occur. There is no evidence that SO_2 is accumulating in the atmosphere. The increasing quantities discharged into atmosphere must therefore be return in transformed / untransformed form to land or sea. The whole process may produce adverse effect on the environment. Analytic solution of steady state 3-D atmospheric diffusion equation for first order transformation of SO_2 to sulfate and wet and dry deposition of both SO_2 and sulfate is given by Alam and Seinfeld [2]. Lee [3] has also given an analytic solution of the steady diffusion equation. He has analyzed the conversion of gaseous species to particulate pollutant, the role of settling velocity and the effects of dry deposition velocity of gaseous species on the particulate pollutant. Three dimensional diffusion equation for unsteady state solved by Shukla and Chuhan [4] for air pollutants emitted from a time dependent point source forming a secondary pollutant.

In the present paper a mixed finite difference scheme has been used to solve the simultaneous unsteady advection - diffusion equations for primary and secondary pollutants to predict the concentration of pollutant at a particular point. The settling velocity and deposition velocity at the ground surface has been considered in the model. Primary pollutant is emitting from an elevated time dependent source and some part of it is converting into secondary pollutant. No