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Finite Difference Approach for Solving the Mathematical Model of Air Pollution Due to Agrochemicals Dispersion

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Abstract

Quality air access is crucial to both society and the environment. Deterioration in air quality through agricultural pollution presents a substantial risk to human health and animal life. To ensure air quality, there is a need to determine the concentration levels of agrochemicals from the farms to residential areas and consider mitigation. In this paper, unsteady Reynolds-averaged Navier–Stokes equations (RANS) simulations together with the concentration and temperature equations are used to study local agrochemicals pollution dispersion in the neighborhood of big farms relative to residential areas. These areas consist of various types of obstacles such as small houses, local streets, and vegetation. Mathematical numerical simulation of such a flow system was formulated to monitor pollutant concentration of agrochemicals used, within the environment. The vegetation composed of tall trees compared to a porous volume which induces a drag force to the air flowing through it. The agrochemicals were considered passive scalars with no chemical reaction. The numerical scheme used is implemented in MATLAB software, so as to obtain the approximate solutions which were represented in tables and graphs. The results were obtained by varying various flow parameters, notably viscous and turbulent Reynolds, Schmidt, and Peclet numbers. From the results it was observed

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that Reynolds number have insignificant effect on the concentration. The Schmidt number increases, as the species concentration increases. The Peclet number, as it increases so is the energy diffusivity in the environment. The results have shown that there are traces of species concentration at the residential areas. Thus it can be concluded that the residents in the area are affected by the agrochemicals used since some traces are located with in the area.

Keywords: Agrochemicals; Concentration; Air pollution; Modelling

1. INTRODUCTION

Modeling dispersion of air pollutants in the atmosphere is one of the most important and challenging scientific problems. There are several natural and anthropogenic events where passive or chemically active compounds are emitted into the atmosphere. The effect of these chemical species can have serious impacts on our environment and human health. Modeling the dispersion of air pollutants can predict this effect. Therefore, development of various model strategies is a key element for the governmental and scientific communities,[**?**].

Pollution has been the subject of discussion and research in the past and still is of concern to researchers to date. This is due to the increased population and hence numerous human activities taking place to cater for the increased human needs. Everything that surrounds us is directly or indirectly connected to the environment. Not only the man, but also other living beings as well as the nature (volcanic eruptions, earthquakes) have effects on environmental pollution [**?**]. Environmental pollution is present from the very beginning of life, but today it is a serious problem that threatens the survival of mankind.

Today, every person living on planet Earth is worried about environmental pollution because the consequences faced every day, through the air we breathe, the food and water we consume,through pollution and radiation we are exposed to. Also, the consequences of environmental problems are manifested through the lack of natural resources, extinction of plant and animal species, as well as the problems in the global ecosystems and biochemical processes,[**?**].

There are several types of pollution.The types of pollutions are classified in different ways. On the basis of the type of environment being polluted, we may recognize air pollution, water pollution, and land (soil) pollution while on the basis of the kind of pollutant involved, we may have sulphur dioxide pollution, fluoride pollution, carbon monoxide pollution, smoke pollution, lead pollution, mercury pollution, solid waste pollution, radioactive pollution, noise pollution etc. We limit the study to air pollution and therefore we need to understand what air pollution is and how it takes place in our environment.

The statistics of the World Health Organization (WHO) indicate that outdoor air pollution in 2016 was a significant cause of premature mortality, with an average of 4.2 million death cases. This mortality was due to exposure to PM2.5 particulate matter, which causes many diseases such as respiratory, cardiovascular, and cancers.The latter penetrates deeply into the lung, irritate and corrode the alveolar wall, and consequently impair lung function. Therefore, modeling dispersion of air pollutants in the atmosphere becomes one of the most important and challenging scientific problems. There are several natural and anthropogenic events where passive or chemically active compounds are emitted into the atmosphere. The effect of these chemical species can have serious impacts on our environment and human health. Modeling the dispersion of air pollutants can predict this effect, according to,[**?**]. Therefore, the development of various model strategies is a key element for the governmental and scientific communities to facilitate mitigation and policy making.

The study to determine additional population health risks due to pollutants reaching the air space of residential areas during the road-vehicles complex operation was done by [**?**]. To assess the pollution, data observations of the intensity of traffic flow in different time periods in the experimental territories were used.

Guided by the constructed nomogram, taking into account the distribution zone of the air pollution, it was possible to determine population health risk during the road-vehicles complex operation in the city based on the calculation of the hazard coefficient. They concluded that the given data on the hazard coefficient calculation of suspended solids emissions of road-vehicles complex allowed a summary of the risk from all the compartmental road-vehicles complex sources. On the basis of the distance from the road to residential buildings presented in the nomogram, it was possible to determine an additional population health risk due to pollutants reaching the air during the road-vehicles complex operation using a mathematical model of dispersion.

Investigation of concentration dispersion of particulates matter (PM 2.5 and PM10) and its impact on human health in Oman was studied by,[**?**]. The study suggested a hybrid neural and mathematical approaches for analyzing the effect rate of particulate matter (PM2.5 and PM10). They implemented a comparative study to analyze the proposed neural and mathematical models, which predict the future levels of pollutants in a fast, cheap, and safe way. They observed that the Linear regression models achieve fewer results of correlation rate (R), mean square error (MSE), root mean square error (RMSE) (0.7604, 0.0673, 0.2595), respectively. However, the non-linear regression polynomial prediction model obtained excellent results based on the coefficient of determination (R) value of 0.9394 and mean square error (MSE) rate of 0.0209, and root mean square error (RMSE) value of 0.1447. All the results were correctly verified based on suitable mathematical methods.

Modeling of air pollution due to automotive vehicles being among the main sources of urban air pollution was performed for the two avenue tracks, considered as urban linear sources, [**?**]. They calculated the rate of emission source from emission factors, average speed, and the number of vehicles accounted for footage circulating on the promenade at peak times. They determinated the concentrations distributions of total suspended particles (TSP), carbon monoxide (CO), and nitrogen oxide (NO_2) on the mesh receptors from weather, topographic, and sources of emission data. Their results obtained from dispersion maps showed that the pollutants were concentrated around the sources. The CO concentration values exceeded the standard due to the high rate of emission sources. NO_2 concentrations also exceeded the standard for hourly average, attributed to the contribution of heavy vehicles and the emission rates of light vehicles and motorcycles. They concluded that the meteorological and topographical conditions of the area favor the atmospheric pollutants dispersion, that vehicles significantly affect air quality in the region and that the mathematical modeling is a useful tool for the study of atmospheric dispersion.

A two dimensional atmospheric dispersion model for computation of the ambient air concentration of reactive pollutants emitted from ground level sources was described [**?**]. Atmospheric chemical reactions are the most complicated and stiff part of pollutants dispersion equations. Coupling them with other physical transport processes to assemble an integrated dispersion model is a time consuming and complicated matter. Mechanism of reactions can be present in form of ordinary differential equations (ODEs). Different pollutants, however, may present different variability characteristic due to their specific emission patterns, rates of diffusion, and transport and transformation behaviors like atmospheric reactions. In this article, reaction term was combined with other parts of dispersion model by using a mathematical technique. The program can simulate ground level emission sources and only needs meteorological data and emission source parameters. The outputs from the MATLAB® program are presented in graphical form. The program was designed to be user friendly and computationally efficient through the use of variable pollution grids, factorized operations, and memory pre-allocation. Model estimation results show that, pollutant concentration is determined as a function of distance downwind and distant from the surface. Conservation of mass equations for an array of cells or nodes are solved simultaneously by an implicit finite difference method for different representative atmospheric conditions.

The literature mostly have been designed for vertical and horizontal stack plumes from factories and motor-vehicle emissions. They considered the movement of ammonia, $C0_2$ and PM among other pollutants horizontally released (expelled by large fans and plumes) in close proximity to the ground-level. In this study we consider the release of pollutants(agrochemicals) in air by drones, aeroplanes and other sprinkler machines which diffuse within the environment and carried by wind to residential areas hence affecting human health. These area of study has been neglected and therefore we model the extensive effects of these pollutants on humans.

2. MATHEMATICAL FORMULATION

This section is concerned with the equations that govern the study of turbulent flows. The continuity, momentum, concentration and the energy equations are hereby used. These governing equations are those that facilitate the analysis of pollutants dispersion which forms the basis of our interest in studying the dispersion of agrochemicals from large farms to the residential areas. The governing equations used in this paper are those that govern turbulent flows since we consider to model the dispersion of agrochemical through wind. Therefore, the general mean flow equations for the compressible turbulent flows where effects of density fluctuations are negligible are as given below;

$$\frac{\partial \overline{\rho}}{\partial t} + div\vec{u} = 0 \tag{1}$$

$$\frac{\partial(\overline{\rho}u)}{\partial t} + \nabla(\overline{\rho}u\vec{u}) = -\frac{\partial p}{\partial x} + \mu\nabla.(\nabla(u)) + \left[\frac{\partial\overline{(-\overline{\rho}u'^2)}}{\partial x} + \frac{\partial\overline{(-\overline{\rho}u'v')}}{\partial y} + \frac{\partial\overline{(-\overline{\rho}u'w')}}{\partial z}\right] + S_{mx} \tag{2}$$

$$\frac{\partial(\overline{\rho}v)}{\partial t} + \nabla(\overline{\rho}v\vec{u}) = -\frac{\partial p}{\partial y} + \mu\nabla.(\nabla(v)) + \left[\frac{\partial\overline{(-\overline{\rho}u'v')}}{\partial x} + \frac{\partial\overline{(-\overline{\rho}v'^2)}}{\partial y} + \frac{\partial\overline{(-\overline{\rho}v'w')}}{\partial z}\right] + S_{my} \tag{3}$$

$$\frac{\partial(\overline{\rho}w)}{\partial t} + \nabla(\overline{\rho}w\vec{u}) = -\frac{\partial p}{\partial z} + \mu\nabla.(\nabla(w)) + \left[\frac{\partial\overline{(-\overline{\rho}u'w')}}{\partial x} + \frac{\partial\overline{(-\overline{\rho}v'w')}}{\partial y} + \frac{\partial\overline{(-\overline{\rho}w'^2)}}{\partial z}\right] + S_{mz} \tag{4}$$

And the general scalar transport equation is as follows;

$$\frac{\partial(\overline{\rho}\Phi)}{\partial t} + \nabla(\overline{\rho}\Phi\vec{u}) = \nabla.(\Gamma_\Phi\nabla(\Phi)) + \left[\frac{\partial\overline{(-\overline{\rho}u'\varphi')}}{\partial x} + \frac{\partial\overline{(-\overline{\rho}v'\varphi')}}{\partial y} + \frac{\partial\overline{(-\overline{\rho}w'\varphi')}}{\partial z}\right] + S_\Phi \tag{5}$$

we apply the general scalar transport equation on to the concentration and the temperature equation as follows;

$$\frac{\partial c}{\partial t} + \nabla.(\vec{u}c) = \nabla.(D\nabla c) + \left[\frac{\partial\overline{(-u'c')}}{\partial x} + \frac{\partial\overline{(-v'c')}}{\partial y} + \frac{\partial\overline{(-w'c')}}{\partial z}\right] + \mathbf{S} \tag{6}$$

$$\rho C_p\left(\frac{\partial T}{\partial t} + \nabla.(\vec{u}T)\right) = \nabla.(k_e\nabla T) + \left[\frac{\partial\overline{(-u'T')}}{\partial x} + \frac{\partial\overline{(-v'T')}}{\partial y} + \frac{\partial\overline{(-w'T')}}{\partial z}\right] + \mu\phi \tag{7}$$

For the averaged Navier Stoke equations, the averaged concentration equation and averaged temperature equation i.e. equations 1 to 4, equation 6 and 7 we consider the use of the Boussinesq approximation to eliminate the turbulence stochastic nature of the terms on the right hand side (RHS);
The Boussinesq approximation equation is given as;

$$-\rho\overline{u_i^{'}u_j^{'}} = \mu_t\left(\frac{\partial u_i}{\partial x_j}+\frac{\partial u_j}{\partial x_i}\right)-\frac{2}{3}\rho k_e\delta_{ij} \tag{8}$$

3. METHODOLOGY

In this paper, modelling the wind and temperature effects on agrochemicals concentration in the atmosphere over agronomic fields was considered. Therefore, approximation of wind velocities, temperature variations, and pollutant concentration in the environment were obtained. The geometry of the mathematical model considered was as shown in the figure 1 below.

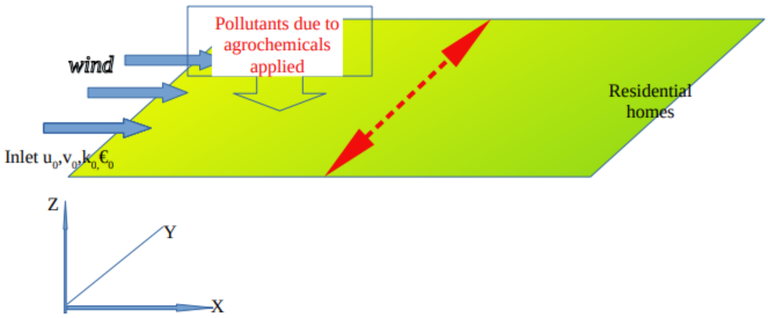

Figure 1: Geometry of the mathematical model used

with reference to the mathematical geometry, figure 1 while making the assumptions that at specific height; density, pressure difference and specific heat are constants, yet fluid inertia forces are infinitely small compared to viscous force and that dispersion of agrochemical pollutants only depend on fluid velocities and coriolis forces and by use of the Boussinesq approximation equation 8, the equations 1 to 4; and equations 6 and 7 becomes;

$$\frac{\partial u}{\partial t}+v\frac{\partial u}{\partial y}=-\frac{1}{\rho}\frac{\partial p}{\partial x}+\frac{\mu+\mu_t}{\rho}\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)+S_{mx}+f_c \tag{9}$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}=-\frac{1}{\rho}\frac{\partial p}{\partial y}+\frac{\mu+\mu_t}{\rho}\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}\right)+S_{mx}+f_c \tag{10}$$

$$\frac{\partial c}{\partial t} + u\frac{\partial c}{\partial x} + v\frac{\partial c}{\partial y} = (D_c + D_{ct})\left(\frac{\partial^2 c}{\partial x^2} + \frac{\partial^2 c}{\partial y^2}\right) + \mathbf{S} \tag{11}$$

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y} = \frac{k_e + k_{et}}{\rho C_v}\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right) + \frac{\mu}{\rho C_v}\left[\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)^2\right] \tag{12}$$

3.1. Boundary and initial conditions for the mathematical model

Since the case is two-dimensional, the sides facing z-direction are set to zeros, which implies that no solution is required in that dimension (see figure 1). The sides facing flow direction are set as inlet,($x = 0$) and outlet,($x = x_N$) boundaries, which are given periodic boundary conditions. The boundary conditions at the wall are specified for each variable and considering no slip condition, the velocities ($u, v = 0$). Also at the side walls, given that there is no solid walls, the adiabatic boundary conditions were considered i.e. $\frac{\partial u}{\partial x} = 0$. This condition applied to all other flow variables. All these are set at the start of simulation for $t = 0$

3.2. Source function modeling

The source term in the lattice Boltzmann (LBGK) model scheme for convection-diffusion equation as proposed by [**?**] was used. They observed that unlike the models proposed previously, the present scheme only requires the source term in order of the Knudsen number by adding a differential operator of the source term to the evolution equation. The scheme can be applied to reaction–diffusion systems directly. Numerical results were found to be in excellent agreement with the analytical solutions.In this paper we used the LBGK scheme and represented the source function as in equation 13 below.

$$S(x, y, u, v) = \exp\left(-c\sqrt{(\mu_x)^2 + (\mu_y)^2}\right) t.\sinh \mu_x(1-x)\cosh \dot{\mu_y}(1-y) \tag{13}$$

where, $\mu_x = \frac{u\pi}{L}$, $\mu_y = \frac{v\pi}{L}$ and c is a constant.

3.3. Surface roughness as a normal distribution function

Terrain features such as buildings, trees etc. are represented in some programs with the use of surface roughness; other programs include such features with the combination of 3D geometry and roughness. Surface roughness strongly affects wind flow separation and recirculation at hilly terrains [**?**]. Vertical mixing of a pollutant plume increases with surface roughness as mechanical turbulence exists over the ground. Common values exist for typical surfaces although most models use specific values that are known to work better according to each physical model employed. The surface roughness in the RANS equations represented as ***smx*** and ***smy*** were considered as normal distribution function in this paper. This function is as given in equation 14 .It act as a drug force to reduce the fluid velocity which in this case acts as a mitigating factor to the pollutants concentration along the field of consideration.

$$\boldsymbol{smx}(x) = H * \tanh\left(\frac{(x - x_{on})}{x_s}\right) - \tanh\left(\frac{(x - x_{off})}{x_s}\right) \tag{14}$$

where H is the height of vegetation cover, x_{on} and x_{off} are the points of start and end of surface roughness cover and ***smy*** $= H$.

4. NONDIMENSIONALIZATION OF GOVERNING EQUATIONS

The process of dimensional analysis is used to eliminate dimensions of variables involved in the model's governing equations. This process starts with selecting a suitable scale against which all dimensions in a given physical model are scaled. The process is of great generality and mathematical simplicity. This process aims at ensuring that the results obtained are applicable to other geometrically similar configurations under similar set of flow conditions.

To do this characteristic quantities were selected that described the flow problem, such as a characteristic length, L , characteristic velocity, U_∞ , characteristic pressure, p_∞, and characteristic temperature, T_∞.

$$\begin{aligned} t^* = \frac{t}{\frac{L}{U_\infty}}, ...x^* = \frac{x}{L}, ...y^* = \frac{y}{L}, ...z^* = \frac{z}{L} \\ , ...u^* = \frac{u}{U_\infty}, ...v^* = \frac{v}{U_\infty}, ...w^* = \frac{w}{U_\infty}, ...p^* = \frac{p - p_\infty}{\rho U_\infty^2}, ... \\ T^* = \frac{T - T_\infty}{\triangle T}, ...C^* = \frac{C - C_\infty}{\triangle C}, ... \end{aligned} \tag{15}$$

where $\triangle$ gives the reference flow variable difference in the flow parameters between a constant wall variable and maximum value i.e. $\triangle C$ is the reference pollutant concentration difference in the flow field such as the one between a constant wall concentration and C_∞. Using these definitions 15 in our specific governing equations 9 to 12 their non-dimensional forms were obtained as in equations 16 to 19

$$\frac{\partial u^*}{\partial t^*} + v^*\frac{\partial u^*}{\partial y^*} = -\frac{\partial p^*}{\partial x^*} + \left(\frac{1}{Re} + \frac{1}{Re_t}\right)\left(\frac{\partial^2 u^*}{\partial x^{*2}} + \frac{\partial^2 u^*}{\partial y^{*2}}\right) + \frac{L}{U_\infty^2}\left(S_{mx} + f_c\right) \tag{16}$$

$$\frac{\partial v^*}{\partial t^*} + v^*\frac{\partial v^*}{\partial y^*} = -\frac{\partial p^*}{\partial y^*} + \left(\frac{1}{Re} + \frac{1}{Re_t}\right)\left(\frac{\partial^2 v^*}{\partial x^{*2}} + \frac{\partial^2 v^*}{\partial y^{*2}}\right) + \frac{L}{U_\infty^2}\left(S_{my} + f_c\right) \tag{17}$$

$$\frac{\partial c^*}{\partial t^*} + u^*\frac{\partial c^*}{\partial x^*} + v^*\frac{\partial c^*}{\partial y^*} = \left(\frac{1}{Sc} + \frac{1}{Sc_t}\right)\left(\frac{\partial^2 c^*}{\partial x^{*2}} + \frac{\partial^2 c^*}{\partial y^{*2}}\right) + \frac{L}{U_\infty \triangle C}\mathbf{S} \tag{18}$$

$$\begin{aligned}\frac{\partial T^*}{\partial t^*} + u^*\frac{\partial T^*}{\partial x^*} + v^*\frac{\partial T^*}{\partial y^*} = \left(\frac{1}{Pe} + \frac{1}{Pe_t}\right)\left(\frac{\partial^2 T^*}{\partial x^{*2}} + \frac{\partial^2 T^*}{\partial y^{*2}}\right) \\ + \frac{\mu U_\infty^2}{\rho C_v \triangle T L^2}\left(\frac{\partial u^*}{\partial y^*} + \frac{\partial v^*}{\partial x^*}\right)^2\end{aligned} \tag{19}$$

The equations 16 to 19 were solved numerically by Gauss-seidel approach using a MATLAB code subject the boundary and initial conditions as stated in the subsection herein. The velocity,temperature and concentration profiles were obtained.

5. RESULTS AND DISCUSSION

Modern agricultural practices use many kinds of chemicals such as fertilizers, pesticides, cleaners, crop preservatives to produce and keeping large amount of high-quality harvest. But every single of these chemicals have dangerous and unforeseen side-effects as like toxicity to non target organisms which cause ecological imbalance. Agrochemical pollutants are carried by wind and their distribution in the environment mainly depends on the type and concentration of pollutants at a source, combined with prevailing weather and topographical conditions. The numerical scheme developed is implemented in MATLAB so as to obtain the approximate solutions. The velocity profiles, temperature and concentration distributions are discussed herein while other parameters such as Reynolds, Peclet, Schmidt and Eckert numbers are being varied.

The table 1, simply shows the variation of velocities, temperature and pollutant concentration with the domain area of study at the end of simulation. The table was exported from the Matlab code at constant values of Reynolds, Schmidt, Peclet and Eckert numbers. From the table it was observed that traces of pollutants dispersed all over the domain area at varied concentration levels. This implied that the people within the residential areas experienced effects of these pollutants. The wind velocity as it accesses the plantation is high but reduces within the area due to the vegetation cover as the sprayed agrochemicals diffused in air. The Reynolds number (*Re*) helps predict flow patterns in different fluid flow situations where for this case we consider a turbulent flow.

It is clearly shown in figure 2 that for increase in dynamic Reynolds number and turbulent Reynolds number, there is an increase of the velocity along domain length. Thus, the velocity is increasing as the value of dynamic Reynolds number and turbulent Reynolds numbers increases. Considering that the wind as carrier in this case, thus the increase in wind velocity propels the dispersion of pollutants in the environment.

u − Velocity	v − Velocity	T − Temperature	C − Concentration
8.762864e-01	9.334390e-01	8.782603e-01	1.083100e+01
6.453696e-01	7.563446e-01	6.413309e-01	2.522396e+01
5.436357e-01	6.582263e-01	5.336023e-01	3.024549e+01
3.110077e-01	3.920938e-01	2.781082e-01	3.920445e+01
2.219799e-01	2.719080e-01	1.668617e-01	4.177436e+01
1.885162e-01	2.107309e-01	9.480379e-02	4.250226e+01
2.117767e-01	2.095446e-01	5.126992e-02	4.130136e+01
2.877940e-01	2.646821e-01	2.641748e-02	3.721432e+01
4.032450e-01	3.696171e-01	1.255919e-02	2.836781e+01
5.357102e-01	5.155113e-01	3.917218e-03	1.202722e+01

Table 1: Variations in velocities, temperature and concentration within the domain area.

Figure 3, shows the variation of principle velocity (*u*) with Surface roughness (*Sm*)at a point x_{on} and x_{off} within the scope. It is observed that there is decrease of the principle velocity (*u*) at this position. This in turn affects the dispersion of agrochemicals by sedimentation. The increased height of the vegetation cover at this point blocks the air flow and thus reduced principle velocity (*u*). Seemingly, the vegetation cover therefore would facilitate agrochemicals dispersion to the residential areas and consequently prevent the people from being affected by the pollutants due to agrochemicals.
The representation of agrochemicals concentration surface over the scope while other parameters of concern are held constant and at zero surface roughness (*Sm*) shows that traces of pollutants along the scope decreases as they are absorbed and trapped within crops in the farm. Traces of pollutants due to agrochemicals sprayed in the area are observed to dispersed all along to the residential area at the extreme end.
Figure 4, shows the variation of agrochemicals concentration with varying surface roughness (*Sm*)at a point x_{on} and x_{off} within the scope. Continued increase of surface roughness (*Sm*) at this position shows increased agrochemicals concentration due to sedimentation. The increased height of the vegetation cover at this point blocks the air flow and thus reduced principle velocity (*u*) which results to increased agrochemicals concentration. Seemingly, the vegetation cover therefore would facilitate agrochemicals deposition at this ar to the residential areas and consequently prevent the people from being affected by the pollutants due to agrochemicals.
The variation of agrochemicals concentration with varying Schmidt numbers is observed as shown in figure 5. The Schmidt number (Sc) is the ratio of the kinematic viscosity to the molecular diffusion coefficient. A Schmidt number is used to

characterize fluid flows in which there are simultaneous momentum and mass diffusion convection processes. From the figure 5, it is observed that as the Schmidt and turbulent Schmidt numbers decreased so does the pollutant concentration along the domain length. This implies that for small Schmidt number, pollutants diffusion dominates, whereas for high Schmidt numbers momentum diffusion will dominate.

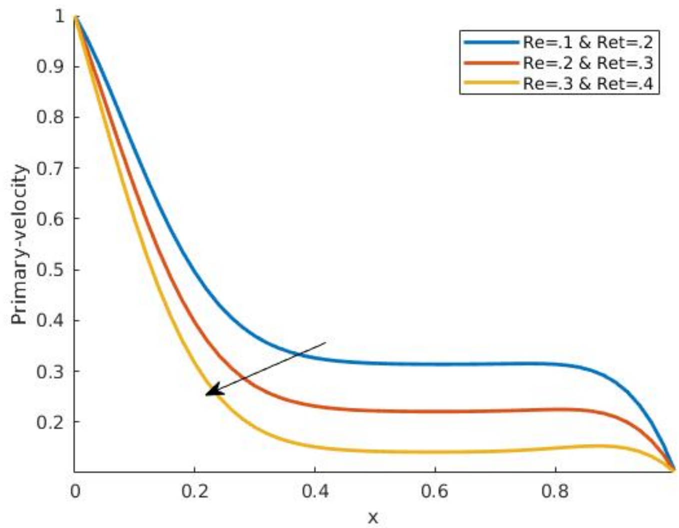

Figure 2: Plot of velocity against the domain length with varying Reynolds numbers

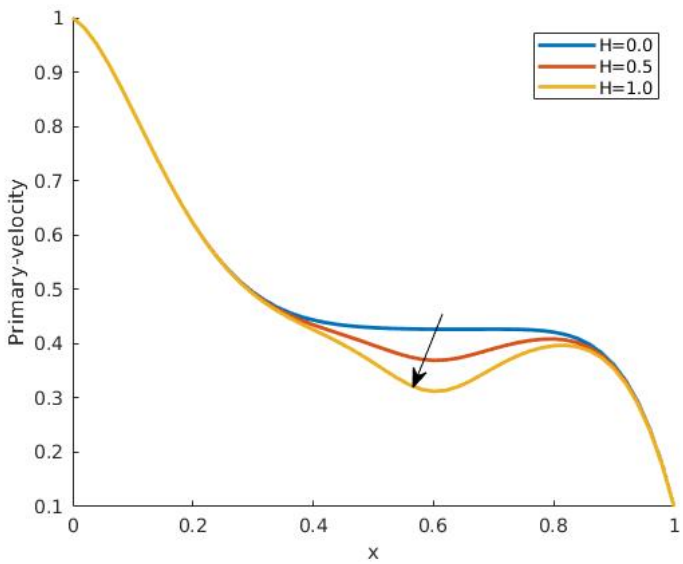

Figure 3: Plot of principle velocity along x with varying vegetation cover

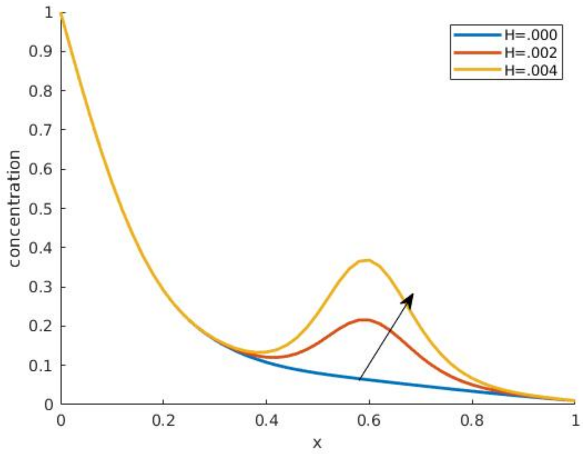

Figure 4: Plot of pollutants concentration with varying vegetation cover height H

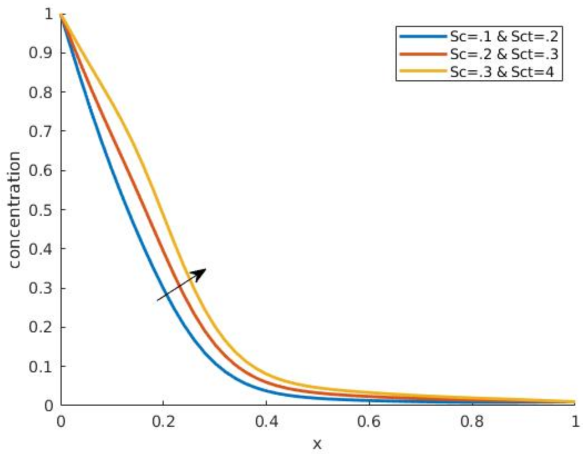

Figure 5: Plot of pollutants concentration with varying Schmidt numbers

The effects of Coriolis forces due to earth rotation is evident affecting the wind velocity which is the pollutant carrier as shown in figure 6.It is observed that, with increase in Coriolis force causes increase in wind velocity hence affecting the propagation of pollutants within the domain area. The Coriolis force applies to movement on rotating objects in this case the earth. The development of weather patterns, such as cyclones(low-pressure systems that suck air into their center) and trade winds, are examples of the impact of the Coriolis effect. The later is observed to affect the wind velocity which consequently affects the dispersion of agrochemical pollutants.

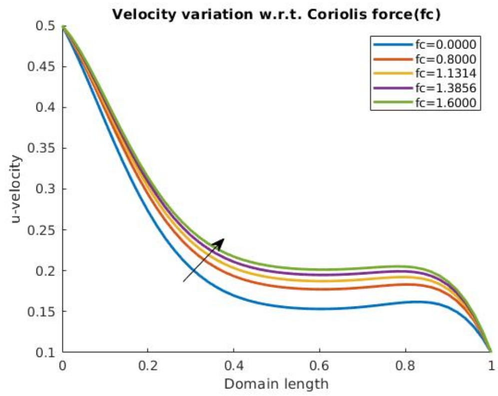

Figure 6: Velocity variation with varying coriolis force(fc)

Surface roughness strongly affects wind flow separation. Common values exist for typical surfaces although most models use specific values that are known to work better according to each physical model employed. In this paper, the surface roughness was considered in form of trees which acts as wind breakers and hence trapping agrochemical particles.

From figure 7, it is observed that the effect of vegetation cover is evident. The figure shows that as the vegetation cover value increases so does the pollutant concentration. This implies that indeed the vegetation trapped agrochemical pollutant as the concentration increases at this position. Therefore, in this case planting of trees in between the agricultural land and the residential areas actually mitigates agrochemical effects on the residents.

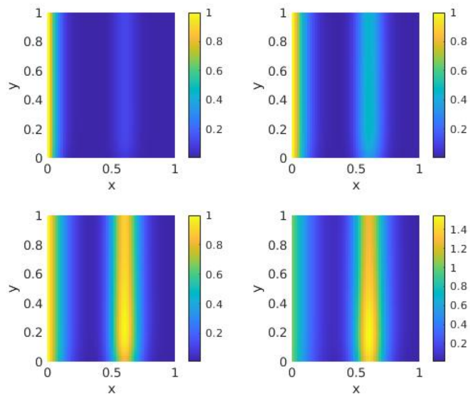

Figure 7: Surface of concentration with vegetation cover over time

Figure 7 shows the pollutant concentration verses the vegetation cover over time. It is observed that over time there were increased levels of agrochemical chemicals trapped around the trees in between the domain area. With this results, it is evident that the land scape of the agronomical areas should be structured in such a way that reasonable vegetation cover can be introduced. This would therefore act to reduce the effect of these agrochemicals to the residents living within the surrounding.

6. CONCLUSION

When the flow is considered turbulent, the flow contains eddying motions of all sizes, and a large part of the mechanical energy in the flow goes into the formation of these eddies which eventually dissipate their energy as heat. As a result, at a given Reynolds number, the drag of a turbulent flow is higher than the drag of a laminar flow. Also, turbulent flow is affected by surface roughness, so that increasing roughness increases the drag. From this study, its has been observed that air pollution due to agrochemicals is eminent in these area. With the results from this research, it is evident that the land scape of the agronomical areas should be structured in such a way that reasonable vegetation cover can be introduced. This would therefore act to reduce the effect of these agrochemicals to the residents living within the surrounding. It can be conclude that, there is need for further study to discover the extent these chemicals can be barred from reaching the residential areas thus reducing the high risk of residents being affected by chronic respiratory diseases.