International Journal of Scientific Research and Engineering Studies (IJSRES)
Volume 2 Issue 10, October 2015
ISSN: 2349-8862

Numerical Study Of County Solid Waste Management At The Dumpsite

Akama Kenanda
Johana K. Sigey
Jeconia A. Okelo
James M. Okwoyo
Kang'ethe Giterere

Abstract: This study presents the development of one dimensional mathematical model capable of simulating simultaneous processes of oxygen flow. It is based on some assumptions like the dumpsite is assumed to behave as a bioreactor in which gas phase generation is over i.e. methanogenic is finished and the humic phase is started. This mathematical model actually describes the oxygen concentration in the dumpsite. The resulting governing equations in the form of partial differential equation (PDE) have been solved by Finite difference method in which Crank-Nicolson scheme is developed. The goal is to study the three transport parameters; effective diffusivity, decay constant rate and porosity on the oxygen concentration which results in degradation of refuse because after a long term processes in the dumpsite. When all the remaining substrate becomes more and more resistant to degradation, microbial activity slows down and the humic phase is reached. During the humic phase, the available degradable organic material is either depleted or either the reactions are too slow to consume oxygen entering the dumpsite. The main focus is to study the governing partial differential equations having three transport parameters and their effect on oxygen concentration with velocity of oxygen kept constant. Solutions of the governing equation are obtained using MATLAB software. The results of the project then are presented in the form of tables and graphs. From the simulated results it is found that for the particular time, oxygen concentration decreases with increase in reaction rate constant (k) with times and depths at the dumpsite. Oxygen concentration at the dumpsite increases with increase in porosity (ε) at a particular time at all depths. Oxygen concentration increases with increase in effective diffusivity (D) time and depths.

Keywords: Oxygen flow, Dumpsite, Partial differential Equation (PDE), Crank-Nicolson Scheme (CNS) Effective diffusivity (D), Decay constant rate (κ) and Porosity (ε)

I. INTRODUCTION AND LITERATURE REVIEW

In this section, a brief introduction is given on solid waste material and Solid waste management System

A. INTRODUCTION

Waste material is an unavoidable by-product of human activities. Economic development, urbanization and improved living standards in cities increase the quantity and complexity of generated solid waste. If accumulated, it leads to degradation of urban environment, stresses natural resource and leads to health problems (CPCB, 2000; NEERI, 1994; UN, 2000). Cities in the world are facing a high level of pollution. The situation in developing countries is more acute. This is partly inadequate provision of basic services like water supply, sanitation facilities, transport, infrastructure and waste collection UNCHS, (2001). On the other hand, waste collection and disposal are very challenging elements in Waste Management.

Anjum and Deshazo, (2010) reports that in many cities, Counties and towns in developing countries, Solid Waste Management (SWM) costs consume between 20% and 50% of Municipal Revenues.

However, the waste collection services levels remain low with only between 50% and 70% of the residents receiving services and most of the disposal being unsafe. Bhatia and Gurnani, (2011) have further observed that the efficiency of collection of waste in urban areas of developing countries vary from 59% to 82%. This suggests that a substantial amount of solid waste remains uncollected. The problem of waste collection and disposal in Kenya is not exceptional.

B. SOLID WASTE MANAGEMENT SYSTEM

Solid waste is a very general term which encompasses all waste materials except hazardous waste, liquid waste and atmospheric emissions, although "most solid waste regulations include hazardous waste within the definition of solid waste" Liu *et al. ,(2012)* solid wastes are divided into three main categories: municipal, industrial and agricultural. Countyl solid waste has several sources such as residential, commercial, institutional, construction and demolition. Industrial solid waste is defined as all solid waste generated from non-manufacturing activities, such as service and commercial establishments. Industrial solid waste does not include office materials, restaurant and food preparation waste, discarded machinery, demolition debris county solid waste includes all solid wastes resulting from the raising of crops or animals on land zoned agricultural by local requirements, including animal manures that are refined to the soils as fertilizer or soil conditions. A solid waste management system consists of prepared plans and plants that are built for final disposal of waste as well as recycling, reuse, composting, and incineration Liu *et al*. (2012).

County solid waste management system deals with the County solid waste from its source of all the operations and transformation of this waste Badran and El-Haggar, (2005). The overall objective of solid waste management is to minimize the adverse environmental effects caused by indiscriminate disposal of solid wastes. Tanaka (1998) further notes the purpose of solid waste management is the preservation of the living environment and improving public health through the restriction of the waste discharge, appropriate sorting, storage, collection, transport, recycling and conservation of a clean living environment.

During the 1980s, major cities in North America realized the necessity to better manage their sewage and solid wastes. Local Governments assumed the responsibility of dealing with urban refuse. Waste services were provided either directly by Government or by private scavenging companies Louis, (2004). These services gradually replaced the spontaneous approach of dealing with waste individually such as dumping, animals slopping in the streets, and scavenging, which prevailed during the 18th century Rathje, (1992).

From the 1920s to 1960s, CSWMS was strongly characterized as engineering – based management Louis, (2004). Along with technological progress, sanitary land filing, incineration, recycling, and other alternative methods emerged. These significantly strengthened the capacity for waste treatments still are the major methods for disposal. Landfill, the cheapest disposal option, became the most widely adopted method during this period of time Rathje *et al.* , (1992).An important shift in a Hitudo emerged in the 1970s at which time the focus gradually shifted to recycling, and material and energy recovery rather than simply burying or burning community's wastes Louis, (2004). A major feature of this shift is that waste management and planning became a more systematic and comprehensive process rather than concentrating on a single task such as the design sanitary dumpsite. This shift is also attributed to legislation that encouraged recycling and recovery and set up guidelines fro operation and monitoring at the state/provincial or even federal/national level Chen, (2008).

The early 1990s, concerns with County Solid Waste (CSW) have been raised from multiple perspectives including health studies, engineering, planning and economics. As Haight, (2009) argues, "owing to the complex and variable nature of municipal solid waste and the various evaluative criteria it can be difficult to identify the optional option(s) for a particular community." As a result of this complexity, a comprehensive approach has emerged in MSWM, trying to employ an optimal combination of various treatment methods and management tools. Regulatory and financial tools, as both incentive and disincentives, are found to be effective, especially concerning waste diversion. Goddard (1995:211) argued that waste management problem is not primarily; one requiring only technical or engineering approaches such as dumpsite and incineration, but that fundamentally it is economic in nature". In terms of treatment methods, it is suggested that a proper combination of feasible treatment methods is needed for better end uses and safe disposal of wastes chen (2008). The solid management models that have been developed since the 1980s vary in goals and methodologies. Waste generation facility site selection, facility capacity expansion, facility operation, vehicle routing scheduling, waste flow and overall system operation are examples of these goals. The techniques that are used include Linear Programming, Mixed Integer Programming, geographical information systems, and network analysis.

The main objective of most of the developed models is to minimize the cost. Some models include the variation of the system over time. These models are called dynamic models. The total cost of the solid waste management system include the transportation cost of the waste to different facilities such as transfer stations, dumpsite, incinerators and also the operational and fixed costs of these facilities Badran and El-Haggar (2010). Details descriptions of most popular mathematical models used in CSWMS are given below.

Bozkurt *et al*. (2000) and Tchobanoglous *et al*. (1993) were investigated that the gas and leachate composition as refusing decomposed Bozkurt, (2001). County solid waste (CSW) dumpsite, leachate contains a number of aquatic pollutants Slack, (2007). At the initial dumpsite stage, the leachate exhibited high heavy metals release, high organic matter content (27 000–43 000 g l−1 of TOC) and low pH (5–6) (Qu 2008) and its quality is regularly maintained by use of pH, alkalinity, oxygen-reduction potential and chemical oxygen demand Doka, (2005), A-stman (2006), Bilgil, (200). But modernized dumpsite includes methods to contain plastic liners and gas dumpsite extraction systems. Here the concern about the impact of excessive materials consumption has given rise to efforts to minimize the efforts waste sand to dumpsite. Degradation processes in the take place dumpsite over a very long period of time. Through this period an increasing understanding of a complex series of chemical and biological reactions Christensen, (1992) that initiates the burial of refuse in a dumpsite developed. After that transition phase, acid phase, methane fermentation phase and maturation phase take place .During aerobic phase oxygen present in the void spaces of freshly buried refuse is rapidly consumed resulting in production of Carbon dioxide. When all the development of gas generation is finished then is dead dumpsite and new phase is generated, i.e. called humic phase. Bozkurt *et al.*, (2000) explained the long term process that may change the leaching behavior of waste during the humic phase.

II. MATHEMATICAL FORMULATION

During the past decay almost all industrialized nations have become aware of the major consequences of waste generated by its industrial and non industrial activities. Modern society generates a large quantity of waste products that may be solid waste or hazardous waste. The sources of these wastes include agriculture, industry mining, milling, and the household's etc. dumpsite Hazardous waste may be fatal, toxic, carcinogenic or teratogenic to human and other organisms. So it has to be managed with proper techniques in an effort to reduce their effect on human health and the environment as unlike water born and air dispersed waste, solid waste will not go away as it will be found in the nature where it is thrown Tchobanoglous, (2008).One of the important solutions to this problem is either to produce less waste or government should create stronger legislation to reduce production of both solid and hazardous waste. Various waste disposal technologies considered are municipal incineration and different dumpsite types, including sanitary, hazardous waste incineration, and waste deposits in deep salt mines, surface spreading of sludge, County wastewater treatment, and building dismantling Doka, (2005). Therefore the collection method is used to dispose of waste still land filling is the most common method there. A combined household/industrial dumpsite in a humid and cold temperate climate is characterized with respect to its chemical composition A-Stman, (2006). In recent times sanitary method dumpsite have replaced the one of the oldest methods of dumping waste material to some unwanted lands as open dumps allowed for developing disease. Actually in sanitary dumpsite the biological decomposition of refusing material takes place. Land filling is the most traditional method of waste disposal as this method is hygienic and relatively inexpensive. Incidents of groundwater contamination by dumpsite leachate have been widely reported since the early 1970s El-Fadel (1997).Bozkurt *et al*., (2000) and Tchobanoglous *et al*.,(1993) were investigated that the gas and leachate composition as refusing decomposed Tchobanoglous, (1993), Slack, (2007). County solid waste (CSW) dumpsite, leachate contains a number of aquatic pollutants Slack, (2007). At the initial dumping sites stage, the leachate exhibited high heavy metals release, high organic matter content (27 000–43 000 g l−1 of TOC) and low pH (5–6) (Qu 2008) and its quality is regularly maintained by use of pH, alkalinity, oxygen-reduction potential and chemical oxygen demand Doka, (2005),A-stman 2006], Bilgil, (2007). But modernized dumping sites include methods to contain plastic liners and dumping sites gas extraction dumpsite systems. Here the concern about the impact of excessive materials consumption has given rise to efforts to minimize the efforts waste sand to dumpsite. Degradation processes in the take place over a very long period of time. Through this period an increasing understanding of a complex series of chemical and biological reactions Christensen (1992) that initiates the burial of refuse in a dumpsite has been developed. After that transition phase, acid phase, methane fermentation phase and maturation phase take place.

Generalized phases in the generation of dumpsite gases. Laner *et al*., (2011) suggested that MSW are potential long-term sources of emissions, in particular leachate and biogas (Laner). The pH and redox conditions are governed by infiltration oxygenated rainwater, by oxygen and carbon dioxide that defuse oxygen into the dumpsites Bozkurt, (2000). Then the condition become aerobics and acidic and that might greatly increase the mobility of heavy metals which are previously been bound in the waste site for hundreds and thousands of years Bozkurt, (1999). Aftercare management of closed dumpsites typically includes monitoring of emissions and receiving systems (e.g. groundwater, surface water, soil, and air) and maintenance of the cover, leachate and gas collection systems, if present in the dumping sites site Laner, (2012).

III. METHODS OF SOLUTION AND GOVERNING EQUATIONS

In this study we have developed Crank-Nicolson numerical scheme and used finite difference method to solve the our model equation. The method obtains a finite system of linear or nonlinear algebraic equations from the PDE by discretizing the given PDE and coming up with the numerical schemes analogues to the equation. We have solved the equations subject to the given boundary conditions. MATLAB software was used to generate solution values in this study.

A. GOVERNING EQUATION

A one-Dimensional model (in Cartesian coordinates) is capable of simulating simultaneous processes of oxygen flow. These models are based on the number of assumptions. The following assumptions have been made for calculating penetration through sealing layer:

- ✓ The porous medium through which migration takes place in homogeneous, isotropic, and saturated.
- ✓ Porosity of the dumpsite liner material (ε), bulk density (ρdry), Darcy's velocity (v), and dispersion coefficient (D), do not vary with period of migration and depth along of Dumpsite.
- ✓ Reaction in the bed is first order irreversible type.
- ✓ Dumpsite assumed to behave as a bioreactor.
- ✓ Direction of flow of oxygen in vertical downward.
- ✓ Gases can be transported by flow and by molecular diffusion in and out of the dumpsite. The final Model

Equation with initial and boundary condition as per Tchobanoglous, (2008).

$$D\frac{\partial^2 C}{\partial x^2} - V\frac{\partial C}{\partial x} - \varepsilon\frac{\partial C}{\partial t} - \kappa C = 0 \qquad (1)$$

Where C(x,t) is oxygen concentration at depth x and time t in the dumpsite.

Discretization is the best numerical technique to solve any partial differential equation. The developed model has been discretized and with use of Crank-Nicolson scheme method. In terms of the discrete variables the derivatives for equation (3.1) are given by

$$\frac{D}{2}\left[\frac{C_{i+1,j}-2C_{i,j}+C_{i-1,j}}{(\Delta x)^2}+\frac{C_{i+1,j+1}-2C_{i,j+1}+C_{i-1,j+1}}{(\Delta x)^2}\right]-V\frac{C_{i+1,j}-C_{i,j}}{(\Delta x)}-\varepsilon\frac{C_{i,j+1}-C_{i,j}}{(\Delta t)}-\kappa\frac{C_{i,j+1}+C_{i,j}}{2}=0 \qquad (2)$$

B. CRANK-NICOLSON SCHEME

With the initial and boundary conditions C(0,t)=1,C(x,0)=0 and

$v = 0.03m/\,year, D = 1m^2/\,year, \varepsilon = 0.4, 0.6, 0.8/\,year, \kappa = 10, 20, 30/\,yr$,

the equation (2) can be discretized into systems of linear equations and written in matrix form as follows

$$\begin{bmatrix} 12.08 & -1 & 0 & 0 & 0 & 0 & 0 \\ -1 & 12.08 & -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 12.08 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 12.08 & -1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 12.08 & -1 & 0 \\ 0 & 0 & 0 & 0 & -1 & 12.08 & -1 \\ 0 & 0 & 0 & 0 & 0 & -1 & 12.08 \end{bmatrix} \begin{bmatrix} C_{11} \\ C_{21} \\ C_{31} \\ C_{41} \\ C_{51} \\ C_{61} \\ C_{71} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \qquad (3)$$

IV. RESULTS AND DISCUSSION

A. EFFECT OF RATE OF DECAY CONSTANT

We solve equation (3) using MATLAB and get the results of the effects of rate of decay constant as shown in table 1 one below

	K=0.2/years	K=0.4/years	K=0.6/years
X=0	$9.5489945x10^{-2}$	$9.784233x10^{-2}$	$9.9940787x10^{-2}$
X=1	$8.1767949x10^{-2}$	$8.3767689x10^{-2}$	$8.5767424x10^{-2}$
X=2	$7.01450054x10^{-2}$	$7.2394842x10^{-2}$	$7.4352868x10^{-2}$
X=3	$6.0789974x10^{-2}$	$6.2559445x10^{-2}$	$6.4639094x10^{-2}$
X=4	$5.2776455x10^{-2}$	$5.4459485x10^{-2}$	$5.6180944x10^{-2}$
X=5	$4.6167899x10^{-2}$	$4.8166724x10^{-2}$	$5.0165059x10^{-2}$
X=6	$4.04542259x10^{-2}$	$4.21188944x10^{-2}$	$4.453066x10^{-2}$

Table 1: Oxygen concentration C(x, t) values for varying decay rate constant at constant $D = 1$ and $\varepsilon = 0.45$

The results in the table 1 above is represented graphically as seen in figure 2a and 2b below

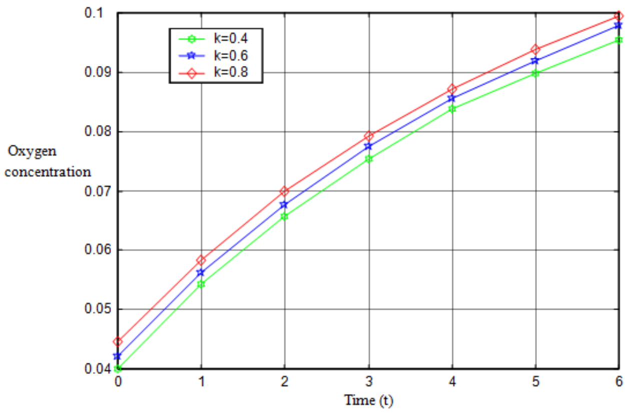

Figure 1(a): Graph of oxygen concentration against time at varying rate of decay

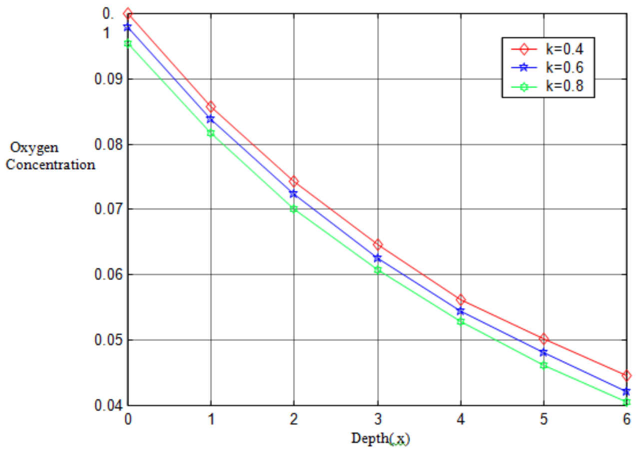

Figure 2(b): Graph of oxygen concentration against depth at varying diffusivity coefficient D

Effect of decay rate constant with respect to depth and time on oxygen concentration in the dumpsite is shown in the Figure 1a and 1b. As we have observed that the oxygen concentration decreases with increase in rate constant in both cases as shown in the Figure 1 (a)- (b). This is due to the fact that with the increase in rate of constant more and more oxygen is consumed in the different type of reactions occurring in the dumpsite at various phases.

B. EFFECT OF EFFECTIVE DIFFUSIVITY

The table 2 shows Effect of effective diffusivities with respective to time and depth on oxygen concentration in the dumpsite

	D=1/year	D=2/year	D=3/year
X=0	$8.363748x10^{-2}$	$9.1454644x10^{-2}$	$9.9940787x10^{-2}$
X=1	$6.99228x10^{-2}$	$7.715988x10^{-2}$	$8.5767424x10^{-2}$
X=2	$5.850632x10^{-2}$	$6.678009x10^{-2}$	$7.4352868x10^{-2}$
X=3	$4.893321x10^{-2}$	$5.6477406x10^{-2}$	$6.4639094x10^{-2}$
X=4	$4.092649x10^{-2}$	$4.712969x10^{-2}$	$5.6180944x10^{-2}$
X=5	$3.422822x10^{-2}$	$4.169898x10^{-2}$	$5.0165059x10^{-2}$
X=6	$2.842875x10^{-2}$	$3.589988x10^{-2}$	$4.453066x10^{-2}$

Table 2: Oxygen concentration values for varying Diffusion coefficient

The results in the table 2 above is represented graphically as seen in figure 2a and 2b below

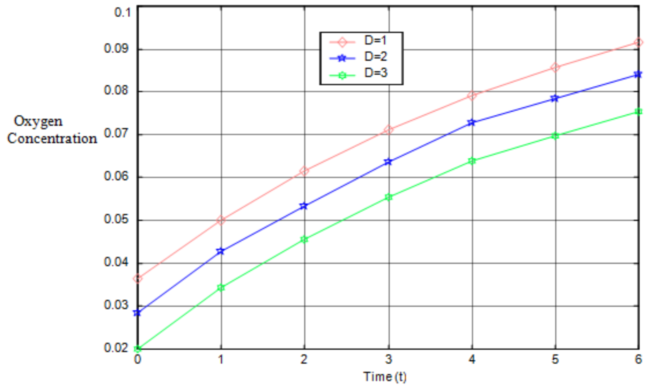

Figure 2(a): Graph of oxygen concentration against time at varying diffusivity coefficient D

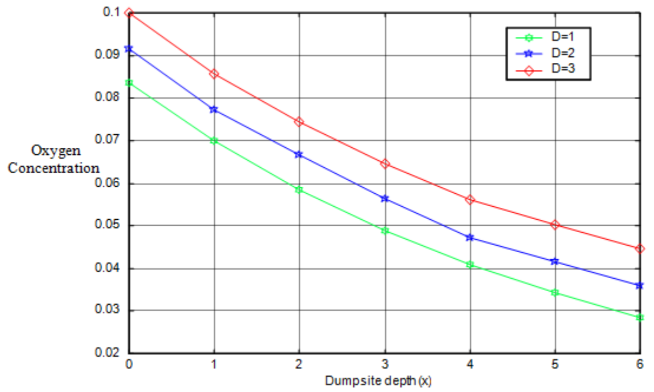

Figure 2(b): Graph of oxygen concentration against depth at varying diffusivity coefficient D

From the simulated results for the particular depth and time, we have found that the oxygen concentration increases with increase in effective diffusivity in both cases as shown in the Figure 2(a)-(b). Therefore, more and more oxygen diffuses in the dumpsite with increasing depth and time. This enables good aeration and movement of microorganisms in the soil thus quick degradation of refuse.

C. EFFECT OF POROSITY

The table 3 shows Effect of porosity on oxygen concentration with respect to the depth and time at the dumpsite.

	$\varepsilon = 0.4$	$\varepsilon = 0.6$	$\varepsilon = 0.8$
X=0	1.194743	1.192369	1.180173
X=1	1.427411	1.421743	1.392809
X=2	1.70539	1.695243	1.643755
X=3	2.037503	2.021355	1.939916
X=4	2.434292	2.4102	2.289436
X=5	2.908354	2.873848	2.701931
X=6	3.474736	3.426686	3.188747

Table 3: Oxygen concentration C(x, t) values for varying porosity at constant

The results in the table 3 above is represented graphically as seen in figure 3a and 3b below

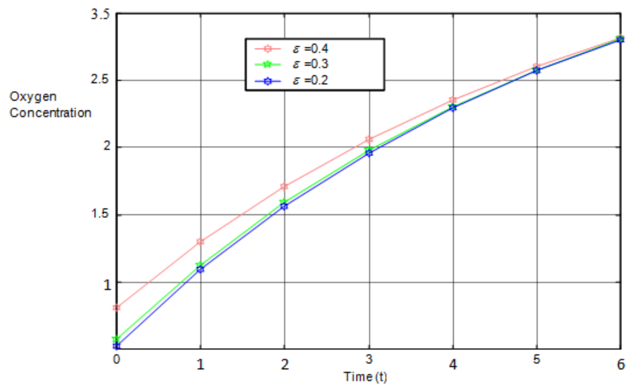

Figure 3(a): Graph of oxygen concentration against time at varying porosity ε

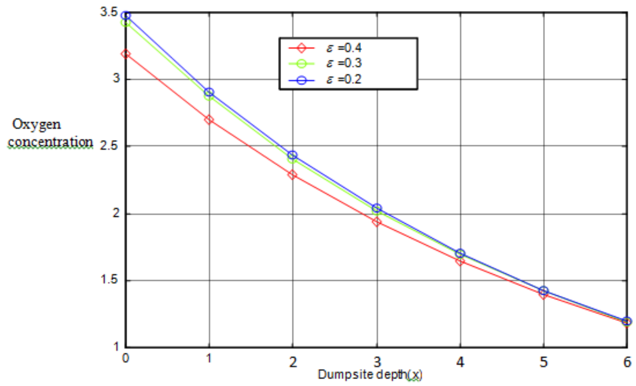

Figure 3(b): Graph of oxygen concentration against depth at varying porosity

Result in the Figure 3(a)-(b) shows that oxygen concentration increases, as the porosity of the waste materials increases and then become a constant after a particular depth. This is due to the fact that at high porosity more and more oxygen is diffused in the dumpsite. With respect to time, the oxygen concentration increases as porosity of the material increases. This enables good aeration and movement of microorganisms in the soil thus quick degradation of refuse.

V. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

From the simulated results we have found that for the particular time, oxygen concentration decreases with increase in reaction rate constant (k) with times and depths at the dumpsite. Oxygen concentration at the dumpsite increases with increases in porosity (ε) at a particular time at all depths. Oxygen concentration increases with increase in effective diffusivity (D) time and depths. No effect is seen in oxygen concentration with the increase or decrease in velocity (v), because in porous media Reynolds number is very less, due to the flow occurs in the Darcy's region. This enables good aeration and movement of microorganisms in the soil thus quick degradation of refuse.

B. RECOMMENDATIONS

Further work is recommended to improve on the results so far obtained for waste management. This may be done by;

- ✓ Considering other means of improving collection of solid waste
- ✓ Using the modern means to recycle the solid waste to come up with useful products

REFERENCES

[1] Agha S. R.(2006). "Optimizing Routing of County solid waste collection vehicles .Deir el Balah - Gaza Strip", The Islamic University Journal.

[2] Anjum M. & Deshazo J. (2010). "Household Demand for Improved Solid Waste Management". The Islamic University Journal.

[3] Ã–stman, M.; Wahlberg, O.; Ã...gren, S. &MÃ¥rtens son, A.,(2006) Metal and organic matter contents in a combined household and industrial landfill. Waste management,26, (1), 29-40.

[4] Badran M. F. and El-Haggar S. M. (2010). "Optimization of Municipal Solid Waste Management System in Port Said" . Egypt:Water Development

[5] Bilgili, M. S.; Demir &A.; Ã–zkaya, B.,(2007) Influence of leachate recirculation on aerobic and anaerobic decomposition of solid wastes. Journal of hazardous materials,143, (1), 177-183.

[6] Bozkurt, S.; Moreno, L. &Neretnieks, I., (1999).Long-term fate of organics in waste deposits and its effect on metal release. The science of the total environment,228, (2-3), 135-152.

[7] Bozkurt, S.; Moreno, L. & Neretnieks, I., (2000).Long-term processes in waste deposits. Science of the total environment,250, (1), 101-21.

[8] Bozkurt, S.; Sifvert, M.; Moreno, L. &Neretnieks, I.,(2001) The long-term evolution of and transport processes in a self-sustained final cover on waste deposits. Science of the total environment ,271, (1-3), 45-168.

[9] Christensen, T. H.; Kjeldsen, P. & Stegmann, R., (1992) Effects of Landfill Management Procedures on Landfill Stabilization and Leachate and Gas Quality. Landfilling of waste: leachate,1,119.

[10] Costi P, Minciardi R, Robba M, Rovatti M & Sacile, R. (2004). An environmentally sustainable decision model for urban solid waste management.Waste Management.

[11] Doka, G.& Hischier, R.,(2005) Waste Treatment and Assessment of Long-Term Emissions (8pp). The International Journal of Life Cycle Assessment,10, (1), 77-84.

[12] El-Fadel, M., Findikakis, A.N.& Leckie, J.O.(1997), Environmental impacts of solid waste landfilling. Journal of environmental management,50, (1), 1-25.

[13] Fiorucci P., Minciardi R., Robba, M. & Sacile, R. (2003).Solid waste management in urban areas development and application of a decision support system Resources. Conservation and Recycling. Gujaranwala Pakistan: Water Development.

[14] Haight, M. E. (2009) Preface, in Haight, M. E. (Ed.) Municipal Solid Waste Management: Making Decisions in the Face of Uncertainty;Waterloo: University of Waterloo Press.

[15] Hasit, Y. & Warner D, B. (1981). Regional solid waste planning with WRAP.,Journal of Environmental Engineering Division, Vol. 107, No. EE3, pp.511-525.

[16] Hsieh, Hsin-Neng & Ho, Kuo-Hua. (1993). Optimization of solid waste disposal system by lineal programming technique", Journal of Resource Management and Technology, Vol. 21, No. 4, pp. 194-201.industry2008,3, 177.

[17] Kaila, J. (1987). Mathematical Model for Strategy Evaluation of Municipal Solid Waste Management Systems. Ph.D. thesis, Helsinki University of Technology.

[18] Kaseva, M. E. & Mbuligwe, S. E (2003), Appraisal of Solid Waste Collection Following Private Sector Involvement in Dares Salaam City, Tanzania, Habitat International, 29:353 - 366.

[19] Kyessi, A. & Mwakalinga,V.(2009). GIS Application in coordinating Solid Waste Collection: The Case of Sinza Neighbourhood in Kinondoni Municicipality-SDI in Municipality and Natural Resources Management.

[20] Laner D., Crest M., Scharff H., Morris J.W.F.&Barlaz M. A.((2012)), A review of approaches for the long- term management of municipal solid waste landfills, Waste Management 32 ,498–512.

[21] Laner D., Fellner J., &Brunner P. H.((2011)), Future landfill emissions and the effect of final cover installation – A case study, Waste Management 31 ,1522–1531.

[22] Movassaghi,K.K.(2005). Optimally in a waste management system. Journal of Resource Management and Technology, Vol 21,No 4, pp. 184-193

[23] NEERI (1994), Solid Waste Management in Greater Bombay.National Environmental Engineering Research Institute

[24] Qu, X.; He, P. J.; Shao, L. M.& Lee, D. J., (2008)Heavy metals mobility in full-scale bioreactor landfill: Initial stage. Chemosphere,70, (5), 769-777.

[25] Slack, R. J.; Gronow, J. R.; Hall, D. H.& Voulvoulis, N.,(2007) Household hazardous waste disposal to landfill: Using LandSim to model leachate migration.Environmental Pollution,146, (2), 501-509.

[26] Tchobanoglous, G.; Theisen, H.& Vigil, S., (1993).Integrated solid waste management: engineering principles and management issues.McGraw-Hill, Inc.:.Warehouse; Management Science, 9:643-666.