MODELING OF DIAZINON DEGRADATION IN AN ASM USING MS EXCEL

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MODELING OF DIAZINON DEGRADATION IN AN ASM USING MS EXCEL

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CHAPTER I

INTRODUCTION

1.1 PURPOSE

The purpose of this research is to adapt a computer model of the degradation of diazinon, a commonly used pesticide, and to integrate it with an existing activated sludge model, ASM1 (IAWQ, 1987). The modeling is done using Microsoft Excel. Data obtained from the Stillwater wastewater treatment plant is used to check the computer model. This helps to arrive at a model that could be adapted for an existing treatment process in a treatment plant for biodegradation of diazinon, or any other trace organic contaminant

1.2 OBJECTIVE

The objectives of this dissertation are:

- To determine through a survey of the scientific literature, the parameters which influence the biodegradation of diazinon in a wastewater treatment plant,
- To develop the appropriate equation describing diazinon degradation and integrate it into an existing activated sludge model
- To program the selected model (ASM1), including the pesticide degradation component, into a user-friendly format.

CHAPTER II

REVIEW OF LITERATURE

2.1 INTRODUCTION

In this chapter, an assortment of activated sludge models researched by diverse authors is discussed and the papers summarized. In addition, diazinon degradation through various processes is also discussed and has been summarized.

2.2 ACTIVATED SLUDGE MODEL

The activated sludge process was so named by Ardern and Lockett (1914) because it included a process in which large amount of microorganisms were used to stabilize the organic material in the wastewater to be treated. The process, which was initially researched by Dr. Angus Smith in location, has now become a common practice for the treatment of wastewater in the industrial and municipal sectors. The basic principle of the process is that the wastewater to be treated is aerated and is subject to microbial action by an aerobic suspension of bacteria, which then undergoes settling, and if possible recycling. The most significant feature of this type of treatment is that the solids can be removed by settling due to gravity.

In 1987, the International Association on Water Quality to assess various activated sludge models available and to determine the best one after their evaluation (Jeppsson, 1987) formed a group. One of the criteria was that the model should be simple and its prediction of the performance of the process should be reasonable. The group found Activated Sludge Model 1 (IAWQ) to be the most effective and widely used. Jeppsson (1987) goes on to described the working format and the key components of the ASM1, and also summarizes the limitations of the model. The fundamental concepts of the ASM1 model were adopted from the UCT (University of Cape Town) model, which has two substrate and regeneration equations. Monod kinetics were used to depict the growth of various organisms and COD (chemical oxygen demand) was used for the carbonaceous matter. The IAWQ model is contrasted from the UCT model in the fact that in ASM1, the committee believed the biodegradable particulate COD to be hydrolyzed to bCOD (biodegradable chemical oxygen demand) and is released into the bulk liquid, unlike in the UCT model. The method in which the model was presented was simple and easy to comprehend. The number of equations used and the variables used were fewer in ASM1 than in the UCT. The paper goes on to describe the variables used in modeling. The various steps involved in the process are aerobic and anoxic growth of heterotrophs, aerobic growth of autotrophs, decay of autotrophs and heterotrophs, ammonification of soluble organic nitrogen, and hydrolysis of entrapped organics and organic nitrogen. Jeppsson (1987) goes on to explain the eight equations used for activated sludge modeling.

However, the author also makes clear that the ASM1 has its limitations, such as it operates at constant temperature, pH, correction factors and coefficients of nitrification. The effects of inorganic nutrients, substrate concentration gradients, and the reactor configuration are not taken into consideration. The model also cannot handle changes in the wastewater characteristics (Jeppsson 1987).

Jacek and Scott (1996) state that the concentration of dissolved oxygen in the activated sludge system or the aeration intensity has a vital role to play in effective maintenance of a waste water treatment plant. The work they did was refining the then existing ASM1, correcting it for the defect by varying oxygen concentration in the predicted profile of ASM on its longitudinal axis and how it affects the reactor hydraulics. The data required for this study (Jacek and Scott,1996) was obtained from the Rock Creek treatment plant in Hillsboro, Oregon. The mathematical model developed was simulated into a program and was checked with the data obtained. A few factors that influence the flow characteristics were indicated as the determination of organic substances and settling properties of the sludge. The authors also say that the term: (E_L/u*L), which gives the dispersion number, has been used to predict the flow in the reactors. But they argue that the deviation from the ideal flow predicted by the dispersion number should be taken into account. Hence they preferred the dispersed flow model, which assists during the designing of an activated sludge system. The authors also declare that they used the two-film theory for modeling the oxygen transfer, stating that the amount transferred is proportionate to the oxygen

transfer coefficient. A computer program was written in the FORTRAN language and the model was named as DISP. In this program, the S_o (oxygen concentration) and the K_{LA} (oxygen transfer coefficient) values can be varied. Using the data obtained they determined the longitudinal dispersion coefficient and the overall oxygen transfer coefficient. The DISP model developed was found to produce a rational report of the DO concentrations. Finally, they concluded that controlling the activated sludge system by varying the dissolved oxygen concentration is economically beneficial.

2.3 DIAZINON

Diazinon is a commonly used pesticide, which from the runoff mixes with the water and is a problem of which we should be aware of in wastewater treatment. The structure of diazinon is

Figure 1: Structure of Diazinon (www.the-piedpiper.co.uk/th13(e).htm)

Diazinon released into surface waters or soil can be removed by volatilization, photolysis, hydrolysis and biodegradation. These properties have been investigated by

a wide variety of researches. The degradation rate constant for various types of waters and the half lives are tabulated below.

Table 1: Half life values of diazinon in water from various sources (Lartiges and Garriges 1995)

Compound	Temperature (˚C)	Half life d	pH	Water type	Light conditions
Diazinon	4	45	8 – 8.2	River and Well water	Fluorescent
	6	132	7.3	Filtered river water	Dark
	6	181	7.3	Unfiltered river water	Dark
	20	185	7.4	Distilled water	Diffused light
	21	14	8.1	River water	Fluorescent
	22	52	7.3	Filtered river water	Dark
	22	80	7.3	Unfiltered river water	Dark

The degradation of diazinon in water occurs through UV and UV/H_2O_2 treatment also. Shemer and Linden (2006) report the degradation kinetics of diazinon under photolysis. Diazinon and hydrogen peroxide (30%) and de-ionized water were used to prepare solutions for the analysis. The UV sources used for the study were low pressure mercury germicidal lamp (LP) and medium pressure (MP) mercury arc

lamps. The degradation was found to follow pseudo first order reaction kinetics. When diazinon was subjected to UV light, the absorption spectrum was found to peak between 200 to 280 nm. Hence they concluded that diazinon had the potential to undergo photolysis by any wavelength below 280nm. After photolysis, quantification of diazinon and its intermediates was performed by liquid chromatography. Calibrations were made using aqueous dilute solutions of analytical standards dissolved in methanol. The degradation constants found are tabulated below.

Table 2: Photo degradation rate constants for diazinon (Shemer and Linden 2006)

UV lamp	H_2O_2 (mg/L)	K_d (cm^2/mJ)	Φ (mol/E)
LP	0	4.61×10^{-4}	0.086
	25	9.91×10^{-3}	
	50	1.3×10^{-2}	
MP	0	2.48×10^{-4}	0.058
	25	8.96×10^{-3}	
	50	1.24×10^{-2}	

Table 3 shows the pseudo first order rate constants and quantum yield values for diazinon as a function of solution pH.

Table 3: Direct photolysis rate constants for diazinon (Shemer and Linden 2006)

pH	Φ ($\times 10^{-2}$ mol/E)	K_d ($\times 10^{-4}$ cm^2/mJ)
4	3.97 ± 0.73	1.553 ± 0.289
7	3.84 ± 0.32	2.256 ± 0.131
10	6.97 ± 0.29	6.97 ± 0.324

Badawy et al., (2006) to explore the possibility of removing organophosphorous pesticides from wastewater, used the same process of photo degradation of diazinon. The advanced oxidation processes use a combination of oxidants and UV radiation to produce free hydroxyl radicals which can be used to oxidize the organic pollutants. According to the authors, three pesticides were used as model substances of organophosphorous pesticides for the analysis. Synthetic solutions with a concentration of 50 ppm of diazinon were used for the analysis. The dosage of hydrogen peroxide was decided based on the stoichiometric ratio with respect to chemical oxygen demand. Both the Fenton and the Photo Fenton processes produced free hydroxyl radicals, which were used for removal of the organo phosphorous pesticides. The authors also found that the formation of the free hydroxyl radicals also depends on the pH, initial concentration of hydrogen peroxide and ratio of organic load and hydrogen peroxide. They reported that the kinetics of degradation followed the following relationship:

$\ln [TOC]/[TOC]_o = -k_o * t$ (pseudo first order kinetics)

They concluded from the analysis that the highest degradation rate was through the combination of a homogenous system of UV/ H_2O_2. The operating conditions were found to be optimum at pH of 3, with COD: H_2O_2 ratio of 4:4.1 and H_2O_2:Fe^{2+} ratio of 100:1. According to the author, the advantages of this degradation process are less energy demand, low investment, efficiency and formation of harmless byproducts. Another method by which diazinon can be degraded is ozonation. Young Ku et al., (1998), reported this. Diazinon solution was filled in the reactor through which ozone containing gas was passed for a period of five hours. At regular time intervals samples were withdrawn from the sampling port and were analyzed for diazinon. The authors reported that the hydrolytic rate constant of diazinon increased with decrease in pH value which shown in Table 4.

Table 4: Pseudo first order rate constants of diazinon (Young Ku et al., 1998)

Effect	Level	K_d (min^{-1})
pH	5	0.127
	7	0.106
	9	0.112
	11	0.121
Alkalinity (mM HCO_3)	0	0.125
	1	0.125
	10	0.113
Γ (˚C)	15	0.111
	25	0.125
	33	0.106
P(atm)	1	0.121
	2	0.234

From the results of the experiment, the authors reported that complete decomposition of diazinon in aqueous solution can be achieved by ozonation in 60 min. They also found that the rate of degradation was independent of solution pH, alkalinity and temperature.

Though the above discussed methods help in removal of diazinon, very few articles are available on the biodegradation of diazinon. Lartiges et al., (1995) collected waters from various sources, spiked them with organo phosphorous and organo nitrogen pesticides and stored them in bottles and studied the degradation kinetics over a period of six months. Diazinon was one of the sample pesticides used for determining the degradation of organo phosphorous pesticides. Results of this study are shown in Table 5.

Table 5 Half-life of diazinon in various water types (Lartiges et al., 1995)

Compound	$T_{1/2}$ River water (d)	$T_{1/2}$ Filtered river water (d)	$T_{1/2}$ Sea water (d)
Diazinon	43	52	47

The authors concluded that many factors affect the degradation of organo phosphorous and organo nitrogen pesticides in water like the pH, chemical composition of the wastewater, particulates, and light.

No published research was found focused on the fate of diazinon in wastewater treatment plants. However, other trace organics have been investigated under these conditions.

Joss et al., (2004), researched trace organics degradation that correlates to the degradation of diazinon, which is a trace organic. The authors designed a biological degradation model for removal of estrogen from the municipal wastewater. The authors conducted various spiked batch experiments. The batch experiments were sampled at various intervals from the aerobic zone of the waste water treatment plant. A blank test was also performed without the sludge but spiked with estrogen. The degradation kinetics were assumed to be pseudo first-order. The authors developed this equation:

$$r = -k_{bio} * SS * C_{w,bulk}$$

where r = reaction rate

k_{bio} = pseudo-first order constant for biological degradation [L g $SS^{-1}g^{-1}$]

SS = sludge concentration [g SSL^{-1}]

Cw,bulk = soluble estrogen concentration in the bulk liquid phase [ng L^{-1}]

Using the degradation curve a model was built. Because of the experiment, the authors report that the biological degradation of estrogen samples in a conventional activated sludge process with nitrification and denitrification was greater than 90%.

Cometabolism is a general approach used for degradation of hazardous materials, which can be defined as the degradation of the desired substance depending on the presence of another compound. Cometabolic degradation generally requires a growth substrate along with the substance to be cometabolized.

Another limitation of ASM1 is that it is not designed to address degradation of trace organic contaminants. Subsequent works have sought to adapt ASM1 for this purpose. Pesticides, however, have received little attention, despite concerns about pesticide concentration in WWTP effluents.

CHAPTER III

METHODOLOGY

3.1 INTRODUCTION

The research involved the programming of the ASM1 using the basic Manod kinetic equations from Wastewater Engineering and Reuse by Metcalf and Eddy (2004) model into Microsoft Excel. Additional equations were adapted for the degradation of diazinon and added to the existing activated sludge model 1 that was programmed in Microsoft Excel.

3.2 ACTIVATED SLUDGE MODELING

The activated sludge process designed as a computer model in MS Excel used the equations given below which were taken from Wastewater Engineering and Reuse by Metcalf and Eddy (2004). The definitions for the variable is given in the appendix.

$$X = (SRT/\tau)*[Y*(S-S_0)/(1+K_d*SRT)] \quad \text{----------(1)}$$

$$SRT = V/Q = \tau \quad \text{----------(2)}$$

$$S_0-S = (V/Q)*[KXS/(K_s + X)] \quad \text{----------(3)}$$

$$P_{XT,VSS} = X_T*V/SRT \quad \text{----------(4)}$$

$$X_T = X+ X_i \quad \text{----------(5)}$$

$$X_T = (SRT/\tau)*[Y*(S-S_0)/(1+K_d*SRT)] + [f_d*k_d*X*SRT] + [X_{o,i}*SRT/\tau] \quad \text{----------(6)}$$

$$P_{X,VSS} = [f_d*k_d*X*V] + [X_{o,I}*Q] + [Q*Y*(S-S_0)/(1+K_d*SRT)] \quad \text{----------(7)}$$

$$P_{X,VSS} = [Q*Y*(S-S_0)/(1+ K_d *SRT)] + [X_{o,I} *Q] + [f_d*k_d* Y*(S-S_0)*SRT/(1+K_d *SRT)] \quad (8)$$

$$P_{X,TSS} = A/0.85 + B/0.85 + C + Q*(TSS_o - VSS_o) \quad (9)$$

$$\text{Mass of MLVSS} = X_{VSS}*V = P_{X,VSS}*SRT \quad (10)$$

$$\text{Mass of MLSS} = X_{TSS}*V = P_{X,TSS}*SRT \quad (11)$$

$$Y_{obs} = Y/(1+K_d *SRT) + [f_d*k_d* Y*SRT/(1+ K_d *SRT)] \quad (12)$$

$$R_o = Q*(S_o-S) - 1.42*P_{X,bio} \quad (13)$$

$$F/M = QS_o/VX = S_o/ \tau X \quad (14)$$

$$L_{org} = Q*S_o/V*10^3 \quad (15)$$

The model was validated by various input data obtained theoretically from the text book *Wastewater Engineering and Reuse* by Metcalf & Eddy (2003).

3.3 INPUTS

The various values such as influent BOD, COD, and various constants were provided as inputs to the model. The values were obtained from literature. And the output such as effluent COD, BOD and others are found. The inputs were the values taken from 8-2, a sample problem from Wastewater Engineering and reuse by Metcalf & Eddy (2004). All the constants (i.e) kinetic coefficients used were taken from table 8-10 (Activated sludge kinetic coefficients) & 8-11(Activated sludge nitrification kinetic coefficients) of Wastewater Engineering and reuse by Metcalf & Eddy (2004).

Wastewater characteristics (from the sample problem):

BOD = 140 g/m^3 (= mg/L)

sBOD = 70 g/m^3

COD = 300 g/m^3

sCOD = 132 g/m^3

rbCOD = 80 g/m^3

TSS = 70 g/m^3

VSS = 60 g/m^3

TKN = 35 g/m^3

NH_4-N = 25 g/m^3

TP = 6 g/m^3

Alkalinity = 140 as $CaCO_3$

Design characteristics (from the sample problem):

Q = 22,464 m^3/d

bCOD/BOD = 1.6

SRT = 5 d

TKN peak/average safety factor = 1.5

X_{TSS} = 3000 g/m^3

Depth of basin = 4.9 m

Aeration characteristics(from the sample problem):

DO = 2 g/m^3

Aeration factor for BOD removal $\alpha = 0.5$

Aeration factor for nitrification $\alpha = 0.65$

Aeration factor for both BOD removal and nitrification $\beta = 0.95$

Diffuser fouling factor $F = 0.9$

Assumed kinetic coefficients(from table 8-10 & 8-11 in Metcalf and Eddy's Wastewater Engineering and Reuse, 2004 Edition):

$K_s = 20\ g/m^3$

$\mu_m = 3.5\ g/g.d$

$k_d = 0.088\ g/g.d$

$Y = 0.4$ g VSS/g bcod

Following steps were followed to program the Monod kinetic equations in Microsoft Excel:

- Using the influent biochemical oxygen demand, the biodegradable chemical oxygen demand was calculated in the model
- Then the difference of chemical oxygen demand and the biodegradable chemical oxygen demands gave the non-biodegradable chemical oxygen demand
- Using the influent soluble chemical and biochemical oxygen demand the soluble effluent chemical oxygen demand concentration was determined
- Using the values obtained as above mentioned in the model, the non-biodegradable volatile suspended solids in the system was calculated

- Then the substrate concentration was figured using the given input values that were in turn used to find the total solids wasted daily
- Then the total and volatile suspended solids in the system were calculated.
- The net wasted solids produced each day in terms of total suspended solids were determined
- Using the values obtained mixed liquor suspended and volatile suspended solids were calculated, which in turn was used to calculate the required reactor volume
- Then the retention was calculated in days
- The values obtained from the calculations were used to determine the food to microorganism ratio and the volumetric loading of the biochemical oxygen demand
- Finally, the observed yield and the oxygen demand were calculated.

3.4 DIAZINON DEGRADATION MODELING

In case of modeling diazinon degradation kinetics into the model, based upon the rate of the reaction, two different cases were designed. The first case was designing assuming that the reaction follows first order reaction kinetics and the second being that the reaction follows pseudo-first order reaction kinetics.

$\text{Ln } C = \ln C_0 - K' \times t$

This can also be written as:

$C = C_o \times e^{(-k' \times t)}$ where, K'=kX

First order reaction kinetics:

$C=C_o e^{(-k \times t)}$

The degradation reaction may be cometabolic. This is discussed in detail in section 2.3.

3.5 OTHER SOFTWARE

There are various models available in the market, which help an environmental engineer in making decisions regarding an activated sludge process, such as SASSPRO V2, ASM1, ASM2, ASM3 and others. When compared to these software packages, the current model is much more user friendly and cost effective. It also has provisions for further improvement as and when needed according to requirements.

CHAPTER IV

RESULTS

4.1 OUTPUTS

After all the inputs were put into the model designed in Microsoft Excel. The outputs were:

bCOD = 224 g/m^3

nbCOD = 76 g/m^3

$sCOD_e$ = 20 g/m^3

nbVSS = 20 g/m^3

iTSS = 10 g/m^3

S = 1.8 g bCOD/ m^3

$P_{x,vss}$ = 1468 kg VSS/d

$P_{x,tss}$ = 2412.7 kg/d

MLVSS = 9637 kg

MLSS = 12,064 kg

Fraction VSS = 0.8

MLVSS = 2400 g/ m^3

F/M = 0.33 kg/kg.d

BOD loading = 0.78kg/ m^3.d

$Y_{obs,tss}$ = 0.77 g TSS/ g BOD

$Y_{obs,vss}$ = 0.61 g VSS/ g BOD

R_0 = 120.5 kg oxygen/h

$P_{x,bio}$ = 1154.7kg/VSS.d

S_e = 8.95 g/ m^3

The outputs produced were compared to the theoretical values in the solution of the example problem from Metcalf and Eddy, the results prove that the model was effective.

As far as Diazinon is concerned, the half –life of the pesticide was found to be 80 days after extensive research through the limited material and articles that were found on diazinon degradation. Using the half-life, the rate constant was determined and there by the effluent diazinon concentration was also found.

Table 6 Input and output values (example 1)

Input	Output
BOD = 140 g/m^3 (= mg/L)	bCOD = 224 g/m^3
sBOD = 70 g/m^3	nbCOD = 76 g/m^3
COD = 300 g/m^3	$sCOD_e$ = 20 g/m^3
sCOD = 132 g/m^3	nbVSS = 20 g/m^3
rbCOD = 80 g/m^3	iTSS = 10 g/m^3
TSS = 70 g/m^3	S = 1.8 g bCOD/ m^3
VSS = 60 g/m^3	$P_{x,vss}$ = 1468 kg VSS/d
TKN = 35 g/m^3	$P_{x,tss}$ = 2412.7 kg/d
NH_4-N = 25 g/m^3	MLVSS = 9637 kg
TP = 6 g/m^3	MLSS = 12,064 kg
Alkalinity = 140 as $CaCO_3$	Fraction VSS = 0.8
Q = 22,464 m^3/d	MLVSS = 2400 g/ m^3
bCOD/BOD = 1.6	F/M = 0.33 kg/kg.d
SRT = 5 d	BOD loading = 0.78kg/ m^3.d
TKN peak/average safety factor = 1.5	$Y_{obs,tss}$ = 0.77 g TSS/ g BOD
X_{TSS} = 3000 g/m^3	$Y_{obs,vss}$ = 0.61 g VSS/ g BOD
Depth of basin = 4.9 m	R_0 = 120.5 kg oxygen/h
DO = 2 g/m^3	$P_{x,bio}$ = 1154.7kg/VSS.d
Aeration factor for BOD removal α = 0.5	S_e = 8.95 g/ m^3
Aeration factor for nitrification α = 0.65	
Aeration factor for both BOD removal and nitrification β = 0.95	
Diffuser fouling factor F = 0.9	
K_s= 20 g/m^3	
μ_m = 3.5 g/g.d	

k_d = 0.088 g/g.d Y = 0.4 g VSS/g Bcod	

Table 7 Example 2 (from Stillwater Wastewater Treatment Plant Data)

The constants were assumed to be the same values used in the example 1.

Inputs	Outputs
SRT = 6.3 d Q = 24506.75 m^3/d TSS = 2974 g/ m^3	bCOD = 203.2 g/ m^3 nbCOD = 96.8 g/ m^3 effluent COD = 20 g/ m^3 nbVSS = 27.42 g/ m^3 iTSS = 174 g/ m^3 Px,vss = 2099.26 kg/d Px,tss = 6591.66 kg/d MLVSS = 41527.49 kg MLSS = 41527.29 kg F/M = 0.14 Px,bio = 1567.12

The outputs from example 2 were values from the City of Stillwater Wastewater treatment plant was used to validate the model, indicates that the model predicts with reasonable accuracy the expected output values.

From the values of diazinon in the influent and effluent of the City of Stillwater Wastewater treatment plant, the degradation rate constant, k, of diazinon was calculated as follows:

Do (Diazinon concentration in influent) = 8 mg/L

D (Diazinon concentration in effluent) = 0.1 mg/L

T = 6.3 d

X = 2974 mg/L

K’ = [ln(Do)-ln(D)]/t

K = K’/X

The degradation rate constant was found to be 0.00233 L/mg/d, assuming the degradation follows pseudo first order kinetics.

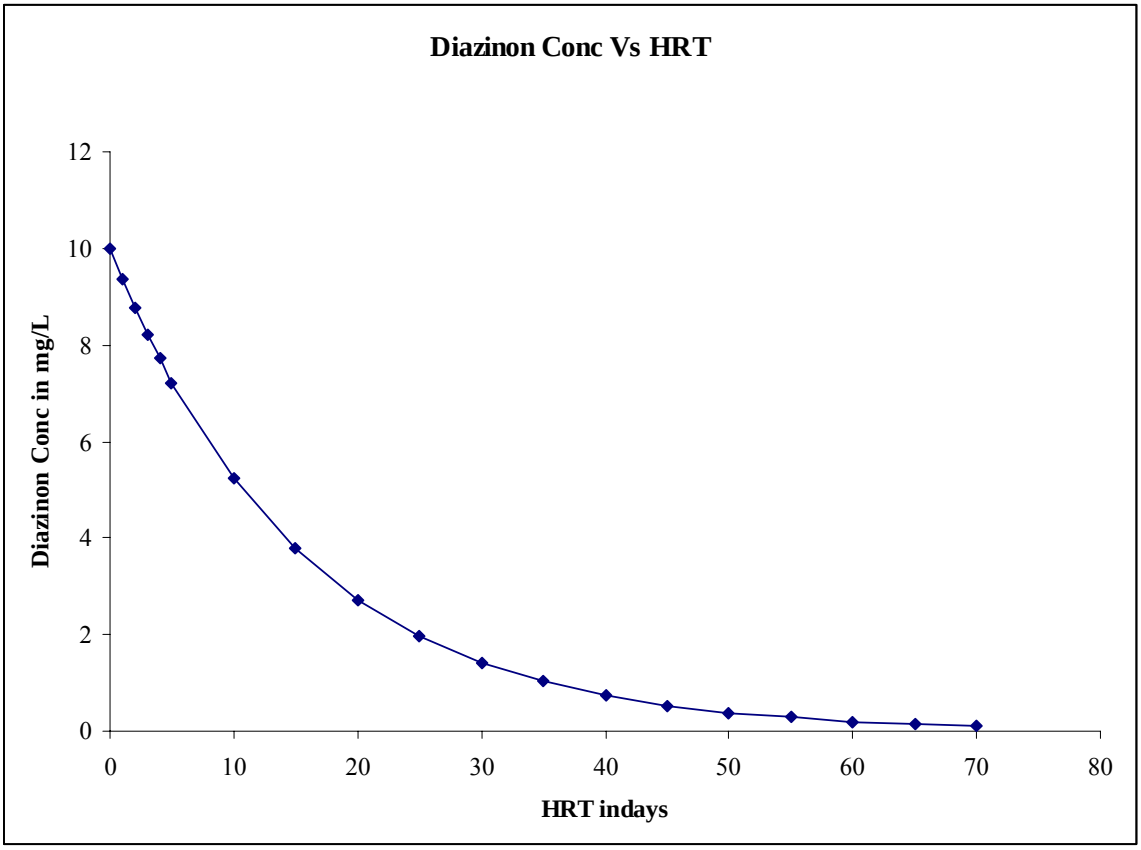

Fig 2: Diazinon concentration Vs HRT

The plot given above shows the graph drawn between the diazinon concentration and the hydraulic retention time.

4.4 RECOMMENDATIONS

By performing experiments and varying the parameters involved in the diazinon degradation such as the biomass, which would help in determining the effect of various parameters on the degradation kinetics. This would be helpful in further improving the model. To find the exact kinetics followed by the degradation process,

further studies and research is to be done, which would help in refining the model designed.

CHAPTER V

CONCLUSION

The model was found to be validated from the results of using the theoretical values. From the literature review, it was evident that the degradation of diazinon followed pseudo first order reaction kinetics. The model also predicts the diazinon degradation values accurately, which was determined from the values obtained from the Stillwater treatment plant.

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APPENDIX

Q = influent flow rate, m^3/d

V = reactor volume, m^3

X_o = concentration of biomass in influent, g VSS/ m^3

Q_w = waste sludge flowrate, m^3/d

X_e = concentration of biomass in influent, g VSS/m^3

X_R = concentration of biomass in return line from clarifier, g VSS/m^3

R_g = net rate of biomass production, g VSS/m^3d

X = concentration of biomass in the reactor, g/ m^3

U = specific substrate utilization rate, g BOD or COD/ g VSS d

So = influent soluble substrate concentration, g BOD or bsCOD/ m^3

S = effluent soluble substrate concentration, g BOD or bsCOD/ m^3

τ = hydraulic detention time, V/Q,d

$P_{X,VSS}$ = total solids wasted daily, g VSS/d

X_T = total MLVSS concentration in aeration tank, g VSS/ m^3

SRT = solids retention time, d

$X_{o,I}$ = nbVSS concentration in influent, g/ m^3

X_i = nbVSS concentration in aeration tank, g/ m^3

$r_{X,I}$ = rate of nbVSS production from cell debris, g/ m^3d

$P_{X,TSS}$ = net wasted activated sludge produced each day, measured in terms of total suspended solids, kg/d

TSS_o = influent wastewater TSS concentration, g/ m^3

VSS_o = influent wastewater VSS concentration, g/ m^3

R_o = oxygen required, kg/d

$P_{X,bio}$ = biomass as VSS wasted per day, kg/d

COD = chemical oxygen demand

BOD = biochemical oxygen demand

VITA

Daphne Rajenthiram

Candidate for the Degree of

Master of Science

Thesis: MODELING OF DIAZINON DEGRADATION IN AN ASM USING MS EXCEL

Major Field: Environmental Engineering

Biographical:

Personal Data:

Education: Masters

Experience:

Professional Memberships: Member of national Scholars Honors Society

Member of ALFA

Name: Daphne Rajenthiram Date of Degree: May, 2007

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: MODELING OF DIAZINON DEGRADATION IN AN ASM USING MS EXCEL

Pages in Study: 27 Candidate for the Degree of Master of Science

Major Field: Environmental Engineering

Scope and Method of Study:

The scope of the study is to design a degradation model for diazinon, a commonly used pesticide which is cause of concern in the treatment plants. It is to be done by designing an activated sludge model in Microsoft excel and by integrating the degradation of diazinon with it. The model will be designed to be user friendly.

Findings and Conclusions:

The activated sludge model that has been designed has been validated by theoretical data. From the literature reviews, it is evident that the degradation kinetics of diazinon follows either first or pseudo first order kinetics.

ADVISER'S APPROVAL: _____