J. Viet. Env. **2016**, Vol. 8, No. 4, pp. 217-222
DOI: 10.13141/jve.vol8.no4.pp217-222

JOURNAL of VIETNAMESE ENVIRONMENT

Research on model-based calculation of greenhouse gas emissions from domestic wastewater treatment systems in Vietnam

Nghiên cứu tính toán phát thải khí nhà kính từ hệ thống xử lý nước thải sinh hoạt dựa trên mô hình tại Việt Nam

Research article

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There are three important greenhouse gases: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), which are generated from the domestic wastewater treatment systems, including on-site and off-site sources. On-site emission of greenhouse gases occurs during process of wastewater treatment, while the off-site emission of greenhouse gases occurs during energy using and other supporting activities of the treatment system. The research established model to calculate greenhouse gas emissions from the domestic wastewater treatment systems, was named No.0 MTH model. The No.0 MTH model was based on balance equations of substrate and biomass, biochemical reactions and Monod kinetics equations for biological treatment reactors and writen by programing Scalable language. Model was calibrated and applied on the Yen So wastewater treatment plant, Ha Noi and the results were obtained at 22^{o}C as follows: off-site GHG emission is 29,560 kgCO_2-eq/day; on-site GHG emission is 13,534 kgCO_2-eq/day, and the rate of on-site emission is 2.506 kgCO_2-eq/ kg BOD. Maybe using the No.0 MTH model to calculate greenhouse gas emissions from the domestic wastewater treatment systems with similar biological methods.

Có 3 khí nhà kính quan trọng là khí Cacbonic (CO_2), khí Mêtan (CH_4), và khí Đinitơ monoxit (N_2O) được phát sinh từ hệ thống xử lý nước thải sinh hoạt gồm cả nguồn trực tiếp và gián tiếp. Phát thải trực tiếp khí nhà kính (KHK) xảy ra trong suốt quá trình xử lý còn phát thải gián tiếp khí nhà kính xảy ra trong quá trình sử dụng năng lượng và các hoạt động phụ trợ bên ngoài hệ thống xử lý. Nghiên cứu đã thiết lập mô hình tính toán phát thải khí nhà kính từ hệ thống xử lý nước thải sinh hoạt, được đặt tên là mô hình MTH số 0. Mô hình MTH số 0 đã dựa trên các phương trình cân bằng khối lượng cơ chất và sinh khối, các phản ứng hóa sinh và phương trình Monod đối với các thiết bị xử lý sinh học và được viết trên ngôn ngữ lập trình scala. Mô hình đã được hiệu chỉnh và được áp dụng tính toán tại nhà máy xử lý nước thải sinh hoạt Yên Sở, thành phố Hà Nội và kết quả thu được tại 22^{o}C như sau: phát thải KNK gián tiếp là 29.560 kg$CO_{2\text{-tđ}}$/ngày và phát thải KNK trực tiếp là 13.534 kgCO_2-tđ/ngày với tỷ lệ phát thải khí nhà kính trực tiếp là 2,506 kg$CO_{2\text{-tđ}}$/ kgBOD. Có thể sử dụng mô hình MTH số 0 để tính toán phát thải khí nhà kính từ hệ thống xử lý nước thải sinh hoạt bằng phương pháp sinh học tương tự.

Keywords: greenhouse gas, on-site and off-site emissions, domestic wastewater treatment plant

1. Introduction

Climate change has been more and more complicated and serious, so the decrease in greenhouse gases (GHGs) emission plays an important role. The emission of GHGs from wastewater treatment systems is the problem of interest and can be measured and assessed to determine the sustainability of treatment systems. There are three main GHGs: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), which are generated from the domestic wastewater treatment systems, including on-site and off-site sources.

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http://dx.doi.org/10.13141/JVE
ISSN: 2193-6471

The off-site GHGs emission includes electricity production; production and transportation of fuel and materials; landfill treatment of the generated solid waste sludge from the on-site processes. The major on-site sources of GHGs generation are aerobic and anaerobic bioreactors, anaerobic digester, biogas leakage, chemical coagulation/flocculation process, and biogas combustion in recovery boilers. The aim of research was to establish the No.0 MTH model to estimate the GHGs emission from wastewater treatment systems. The model was based on balance equations of substrate, biomass, biochemical reactions and Monod kinetics equations for biological treatment reactors; the hypothesis was that during wastewater treatment process, $C_{10}H_{19}NO_3$ and $C_5H_7NO_2$ were used to represent the substrate and the biomass, respectively. The model was solved by numerical method and then was coded. It was obvious that the model could be significantly useful for assessment of domestic wastewater treatment systems in Vietnam, in order to increase the efficiency of wastewater treatment systems for sustainable development and deal with climate change.

2. Materials and methods

2.1. Research objective

The Yen So domestic wastewater treatment plant, Ha Noi was used to calculate the greenhouse gases (GHGs) emission.

2.2. Theoretical basis for the development of No. 0 MTH model

2.2.1. Estimation of the off-site greenhouse gas emissions

The main off-site sources of greenhouse gas emission include electricity production for on-site use, production and transportation of fuel and materials. The overall off-site emission of greenhouse gases is obtained by addition of the produced gases by each source.

$$P_{CO2,\ off\text{-}site} = P_{CO2,\ electricity} + P_{CO2,\ natural\ gas} + P_{CO2,\ material} \quad (2\text{-}1)$$

$$+\ P_{CO2,\ electricity} = QE * \sum (PF_i * EF_i) \quad (2\text{-}2)$$

where:

$P_{CO2,\ electricity}$: The GHG production due to electricity demands of the plant ($kgCO_{2\text{-}td}$/day)

QE: The quantity of electricity used for the operation of the entire plant (kwh/day)

PF_i : Percentage contribution of fuel i to satisfy electricity generation needs of the wastewater treatment systems (%) (Table 1)

EF_i : GHGs emission factor of fuel i in producing GHGs ($kgCO_{2\text{-}td}$/kwh) (Table 2-1)

$$+\ P_{CO2,\ natural\ gas} = [Q_{natural\ gas} * EF_{natural\ gas,CO2}/10^3] + 25 * [Q_{natural\ gas} * EF_{natural\ gas,CH4}/10^3] + 296 * [Q_{natural\ gas} * EF_{natural\ gas,N2O}/10^3] \quad (2\text{-}3)$$

where:

$P_{CO2,\ natural\ gas}$: The off-site GHGs production because of natural gas consumption for space heating in the plant ($kgCO_{2\text{-}td}$/day)

$Q_{natural\ gas}$: The quantity of natural gas used for space heating in the plant (m^3/day)

$EF_{natural\ gas,CO2}$, $EF_{natural\ gas,CH4}$, $EF_{natural\ gas,N2O}$: the overall natural gas CO_2, CH_4 and N_2O emissions factors (g/m^3) (Table 2)

$$+\ P_{CO_2,\mathrm{material}} = \sum_i Q^i_{material} . EF_{materiali} \quad (2\text{-}4)$$

where:

$P_{CO2,\ material}$: The off-site GHGs production because of material consumption in the plant ($kgCO_{2\text{-}td}$/day)

$Q^i_{material}$: The quantity of material used in the plant (kg/day)

$EF^i_{material}$: The emission factor of material i in the plant ($kgCO_{2\text{-}td}$/kg material) (Table 3)

+ The off-site greenhouse gases emission factors are in the below tables:

Table 1. Emission factors for different methods of electricity production [1,2,4]

Fuel types	Hydro	Nuclear	Coal	Other fuel	Bio-energy, wind, tidal
EF_i ($gCO_{2\text{-}eq}$/kwh)	10	9	877	604	11
PF_i (%)	48.78	-	23.07	27.72	0.43

Table 2. Emission factorsfrom production and transportation of fuel (g/m^3) [3]

$EF_{natual\ gas,CO2}$	$EF_{natual\ gas,CH4}$	$EF_{natual\ gas,N2O}$
431.9	2.1	0.000022

Table 3. Emission factors of materials ($kgCO_{2\text{-}eq}$/kg material) [2]

Material types	Methanol	Alkalinity	$FeCl_3 .6H_2O$
$EF_{material}$	1.54	1.74	2.71

2.2.2. Estimation of the on-site greenhouse gases emissions

a. Calculation in the first boundary

The removal of BOD, suspended solid (SS) in the primary clarifier:

$$BOD_{removal,clarifier} = Pr_{clarifier,BOD} \times Q_{o,v} \times S_{o,v} \quad (2\text{-}5)$$

$$SS_{removal,clarifier} = Pr_{clarifier,SS} \times Q_{o,v} \times X_{o,v} \quad (2\text{-}6)$$

where:

$BOD_{removal,clarifier}$; $SS_{removal,clarifier}$: the amount of BOD and SS removal in the primary sedimentation tank, respectively (g/day)

$Pr_{clarifier,BOD}$; $Pr_{clarifier,SS}$: the percentage of BOD_5 and SS removal in the primary sedimentation tank, respectively (%)

$Q_{o,v}$: influent wastewater flow rate (m^3/day)

$S_{o,v}$, $X_{o,v}$: influent substrate and suspended solids concentration, respectively (mg/l)

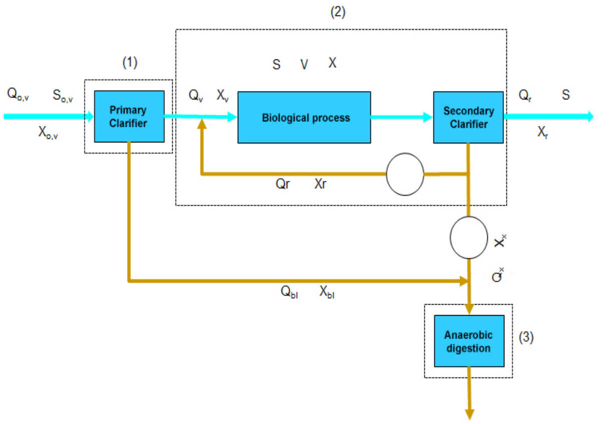

Figure 1. Flowchart of the wastewater treatment system

b. Calculation in the second boundary

The balance equations for substrate and biomass concentrations in the aerobic bioreactor as follows:

$$V.\frac{dS}{dt} = Q_v.S_v - (Q_r.S_r + Q_x.S_x) + r_s.V \quad (2\text{-}7)$$

$$V.\frac{dX}{dt} = Q_v.X_v - (Q_r.X_r + Q_x.X_x) + r_x.V \; ; \quad 2\text{-}8)$$

$$r_s = -\frac{k.X.S}{K_s + S} \quad (2\text{-}9)$$

$$r_x = -Y.r_s - k_d.X \quad (2\text{-}10)$$

where:

V: The volume of the aerobic bioreactor (m^3)

($\frac{dX}{dt}$); ($\frac{dS}{dt}$): the change rate of biomass and substrate concentration with respect to time, respectively (g/m^3.day)

X, S: Substrate and biomass concentrations inside the aerobic bioreactor, respectively (mg/l)

Q_v, Q_r, Q_x : Inflow wastewater rate, outflow wastewater rate and discharge of sludge flow in the aeration tank, respectively (m^3/day)

X_r , S_r : The concentration of effluent biomass and substrate, respectively (mg/l)

r_x: Net rate of biomass production in the aeration tank (g/m^3.day)

r_s: Substrate utilization rate in the aeration tank (g/m^3.day)

In the steady-state condition, $\frac{dS}{dt} = 0$ and $\frac{dX}{dt} = 0$ and using $\frac{1}{SRT} = \frac{YkS}{Ks + S} - k_d$ and $HTR = \frac{V}{Q_v}$

The substrate and biomass concentrations inside the aerobic bioreactor are obtained as:

$$S = \frac{K_s[1 + k_d.SRT]}{SRT.(Yk - k_d) - 1} \quad (2\text{-}11)$$

$$X = \left(\frac{SRT}{HRT}\right)\left\{\frac{Y.(S_v - S)}{1 + k_d.SRT}\right\} \quad (2\text{-}12)$$

The total suspended solid (SS) in the system could be obtained as:

$$X_{Total,SS} = X + X_{nb} + X_{nit} \quad (2\text{-}13)$$

$$X_{nb} = \underbrace{f_d.k_d.X.SRT}_{celldebris} + \underbrace{\frac{X_{nb,v}.SRT}{HRT}}_{non-biodegradableVSS} \quad (2\text{-}14)$$

$$X_{nb,v} = VSS.(1 - \frac{bpCOD}{pCOD}) \quad (2\text{-}15)$$

$$X_{nit} = \left(\frac{SRT_{nit}}{HRT}\right)\left\{\frac{Y_{nit}.N}{1 + k_{d,nit}.SRT_{nit}}\right\} \quad (2\text{-}16)$$

$$P_{SS} = \frac{X_{Total,SS}.V}{SRT} = P_{SS,BOD} + P_{SS,nit} + P_{SS,celldebris} + P_{SS,nbVSS} \quad (2\text{-}17)$$

$$P_{SS,nit} = \frac{X_{nit}.V}{SRT} \quad (2\text{-}18) \; ; \; P_{SS,BOD} = \frac{X.V}{SRT} \quad (2\text{-}19)$$

$$P_{SS,celldebris} = f_d.k_d.X.V \quad (2\text{-}20)$$

$$P_{SS,nbVSS} = Q_v.X_{nb,VSS} \quad (2\text{-}21)$$

$$BOD_{OX} = Q_v(S_v - S) - r_{O2,decay}.(P_{SS} - Q_v.X_{nb,v}) \quad (2\text{-}22)$$

$$VSS_{decay} = 0{,}85.V.(k_d.X + k_{d,nit}.X_{nit}) \quad (2\text{-}23)$$

$$N_2O = Q_v.TKN_v.R_{N_2O} \quad (2\text{-}24)$$

$$CO_{2,BODremoval} = Y_{CO2} . (BOD_{OX} - BOD_{OX,dnt}) \quad (2\text{-}25)$$

$$CO_{2,VSSdecay} = Y_{CO_2,decay}.VSS_{decay} \quad (2\text{-}26)$$

$$CO_{2,dnt} = Y_{CO2,dnt} . N.Q_v \quad (2\text{-}27)$$

$$CO_{2,consumption\ nit} = r_{CO2,nit}.N.Q_v \quad (2\text{-}28)$$

The total amount of CO_2 for the aerobic process can be calculated as follow:

$$CO_{2,production\ in\ aerobic\ process} = CO_{2,BOD\ removal} + CO_{2,VSS\ decay} + CO_{2,dnt} - CO_{2,consumption\ nit} \quad (2\text{-}29)$$

$$CO_{2,N_2Oemission} = 296 * N_2O_{nitrogenremoval} \quad (2\text{-}30)$$

c. Calculation in the third boundary

The total amount of CO_2 and CH_4 production in the anaerobic digester could be calculated as follows:

$$CO_{2,digester} = Y_{CO_2,dr}.BOD_{removal,dr} + Y^{dr}_{CO_2,decay}.VSS^{dr}_{decay} \quad (2\text{-}31)$$

$$CH_{4,digester} = Y_{CH_4,dr}.BOD_{removal,dr} + Y^{dr}_{CH_4,decay}.VSS^{dr}_{decay} \quad (2\text{-}32)$$

$$CO_{2,digestermethane} = Y_{CH_4,combustion}.CH_{4,digesterrecovery} + 23.(CH_{4,digesterdissolve} + CH_{4,digesterleak}) \quad (2\text{-}34)$$

d. Establishing of emission factors of greenhouse gases in wastewater treatment system

In domestic wastewater, $C_{10}H_{19}NO_3$ and $C_5H_7NO_2$ were used to represent the substrate and the biomass, respectively. The chemical reactions in aerobic bioreactor: reactions of biomass decay, nitrification and denitrification as well as the anaerobic decays are as follows:

$$0{,}02C_{10}H_{19}NO_3 + 0{,}01NH_4^+ + 0{,}01HCO_3^- + 0{,}1O_2 \rightarrow 0{,}03C_5H_7NO_2 + 0{,}11H_2O + 0{,}06CO_2$$

$$0{,}05C_5H_7O_2N + 0{,}25O_2 \rightarrow 0{,}2CO_2 + 0{,}05NH_4^+ + 0{,}05HCO_3^- + 0{,}05H_2O$$

$$0{,}02C_{10}H_{19}NO_3 + 0{,}1H_2O \rightarrow 0{,}118CH_4 + 0{,}052CO_2 + 0{,}0025C_5H_7O_2N + 0{,}0175NH_4^+ + 0{,}0175HCO_3^-$$

$$0{,}1275NH_4^+ + 0{,}24O_2 + 0{,}01CO_2 + 0{,}0025HCO_3^- \rightarrow 0{,}0025C_5H_7O_2N + 0{,}125NO_3^- + 0{,}25H^+ + 0{,}1225H_2O$$

$$0,02C_{10}H_{19}NO_3 + 0,184NO_3^- + 0,184H^+ \rightarrow 0,004C_5H_7O_2N$$
$$+0,02NH_4^+ + 0,02HCO_3^- + 0,09N_2 + 0,162CO_2 + 0,22H_2O$$

$$0,02C_{10}H_{19}NO_3 + 0,18H_2O \rightarrow 0,003C_5H_7O_2N + 0,118CH_4$$
$$+0,052CO_2 + 0,017NH_4^+ + 0,017HCO_3^-$$

From the result of reactions, the coefficients of GHG emission are established as follows:

Table 4: The coefficients of GHG emissions

Parameter	Unit	Value
Aerobic process		
Y_{CO2}	$gCO_2/gBOD$	0.33
Y_{VSS}	gVSS/gBOD	0.422
r_{O2}	$gO_2/gBOD$	0.4
Endogenose decay in aerobic process		
$Y_{CO2,decay}$	$gCO_2/gVSS$	1.56
$r_{O2,decay}$	$gO_2/gVSS$	1.42
Anaerobic process		
Y^{an}_{CO2}	$gCO_2/gBOD$	0.28
Y^{an}_{CH4}	$gCH_4/gBOD$	0.235
Y^{an}_{VSS}	gVSS/gBOD	0.035
Endogenose decay in aerobic process		
$Y^{an}_{CO2\ decay}$	$gCO_2/gVSS$	0.58
$Y^{an}_{CH4,decay}$	$gCH_4/gVSS$	0.35
Nitrification process		
$Y_{VSS,nit}$	gVSS/gN	0.55
$Y_{NO3,nit}$	$gN\text{-}NO_3/gN$	0.98
$r_{O2,nit}$	gO_2/gN	4.32
$r_{CO2,nit}$	gCO_2/gN	0.247
Denitrification process		
$Y_{VSS,dnt}$	$gVSS/gN\text{-}NO_3$	0.175
$Y_{CO2,dnt}$	$gCO_2/gN\text{-}NO_3$	2.767
$r_{BOD,dnt}$	$gBOD/gN\text{-}NO_3$	2.059
$r_{methanol,dnt}$	$gCH_3OH/gN\text{-}NO_3$	1.9
Anaerobic decay		
$Y_{CO2,dr}$	$gCO_2/gBOD$	0.28
$Y_{CH4,dr}$	$gCH_4/gBOD$	0.23
$Y_{VSS,dr}$	gVSS/gBOD	0.042
Biomass decay		
$Y^{dr}_{CO2,decay}$	$gCO_2/gVSS$	0.58
$Y^{dr}_{CH4,decay}$	$gCH_4/gVSS$	0.35

3. Results and discussions

3.1. Operational process of No. 0 MTH model

The No.0 MTH model was written by programing Scalable language. Input parameters of the model are: the quantity of electricity used, the quantity of material used, the quantity of material used and treatment capacity, BOD, TSS, TN, temperature of tanks, hydraulic retention time (HRT), sludge retention time (SRT), underflow rate, etc. Through the processes of calculating in the model will be obtained output results, which are off-site and on-site greenhouse gas emissions from the domestic wastewater treatment system. The model operating procedures are described in Table 5 and Figure 2 below:

Table 5. Operational process of No. 0 MTH model

Description	Operational process of No. 0 MTH Model
Inputs	- The off-site greenhouse gases emissions: +The quantity of electricity used +The quantity of natural gas used +The quantity of material used - The on-site greenhouse gases emissions: +Treatment capacity; BOD, TSS, TN +Temperature of tanks +Hydraulic retention time (HRT) +Sludge retention time (SRT) +Underflow rate
Calculation process	Equations for calculation of the off-site greenhouse gases emissions Equations for calculation of the on-site greenhouse gases emissions
Outputs	Emission results of the off-site greenhouse gases Emission results of the on-site greenhouse gases Total emission results of the greenhouse gases

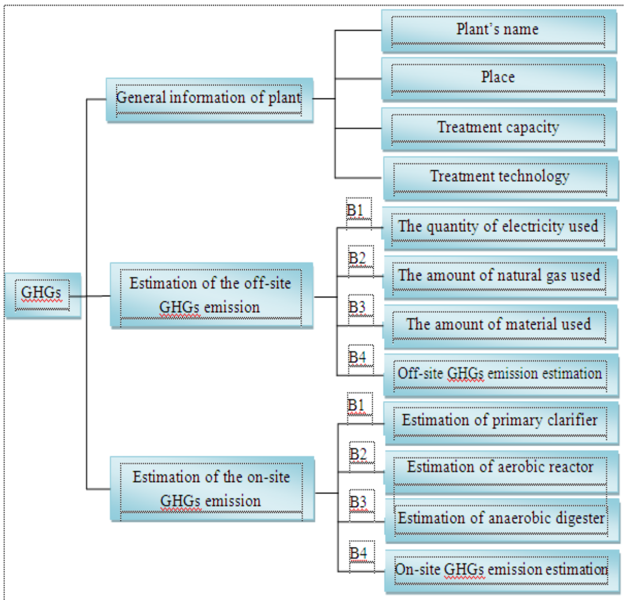

Figure 2. Flowchart of calculating greenhouse gas emissions from domestic wastewater treatment systems by No.0 MTH model

3.2. Research results

3.2.1. Estimation of the off-site greenhouse gases emission

The No.0 MTH model was applied to calculate the greenhouse gas emissions from Yen So domestic wastewater treatment in HaNoi, with a treatment capacity of 120,000 m^3/day. Input parameters of the Yen So Plant and the results of calculation of greenhouse gas emissions indirectly were shown in table 6 and table 7. Through the No.0 MTH model simulated off-site greenhouse gas emissions from Yen So domestic wastewater treatment plants in Hanoi was 29,560.70 kgCO_2-eq / day.

Table 6. Inputs of the Yen So domestic wastewater treatment plant, Ha Noi

Parameter	Unit	Value
Treatment capacity of plant	m^3/day	120,000
The quantity of electricity used	Kwh/day	26,400
The quantity of natural gas used	m^3/day	-
The quantity of material used		-
+ Alkalinity	Kg/day	1,800
+ PAC	Kg/day	6,000
+ Polimer	Kg/day	180

Table 7. Outputs of the off-site greenhouse gases emission of the Yen So wastewater treatment plant, Ha Noi

Result	Unit	Estimation value
$P_{CO2,\ electricity}$	$kgCO_{2-eq}$/day	9,891.50
$P_{CO2,\ natual\ gas}$	$kgCO_{2-eq}$/day	-
$P_{CO2,\ material}$	$kgCO_{2-eq}$/day	19,669.20
$P_{CO2,\ off-site}$	$kgCO_{2-eq}$/day	29,560.70
$P_{CO2,\ off-site}$	ton CO_{2-eq}/year	10,789.60

3.2.2. Estimation of the on-site greenhouse gases emission

The Yen So, Hanoi Plant treated domestic wastewater treatment by aerobic biological methods, combined with nitrogen removal and decomposition of biological sludge using anaerobic methods. Table 8 showed the kinetic parameters in during aerobic treatment, Nitrification and denitrification processes and anaerobic sludge. Table 9 showed the input parameters of the plant. Using No.0 MTH model calculated on-site greenhouse gas emissions from the factory Yen, Hanoi was 13,534.32 kgCO2-eq / day and Emission factor was 2.506 $kgCO_{2-eq}$/kg BOD and shown in Table 10.

Table 8. Kinetic parameters of the domestic wastewater treatment processes

a. Aerobic process

Parameter	Unit	Value at 20°C (K_{20})	Value at 22°C K_T (*)
μ_m	1/day	4	4.58
Y	mg/mg	0.50	0.60
$k = \mu_m/Y$		8	7.63
Ks	mg/l	60	60
k_d	1/day	0.10	0.11
f_d		0.1	0.10

(*) $K_T = K_{20} * \theta^{(T-20)}$

b. Nitrification and denitrification processes

Parameter	Unit	Value at 20°C	Value at 22°C
$\mu_{m,nit}$	1/day	0.7	0.89
Y_{nit}	mg/mg	0.12	0.16
$k = \mu_m/Y$		7.50	5.58
K_N	mg/l	0.5	0.87
$k_{d,nit}$	1/day	0.08	0.04
K_{DO}		1.3	1.3

c. Anaerobic process

Parameter	Unit	Value at 30°C
μ_m^{dr}	1/day	0.26
Y^{dr}	mg/mg	0.08
$k^{dr} = \mu_m^{dr}/Y^{dr}$	1/day	3.3
K_s^{dr}	mg/l	380
k_d^{dr}	1/day	0.03
f_d^{dr}		0.15

Table 9. Input parameters of the Yen So wastewater treatment plant, Ha Noi

	Parameter	Unit	Value
Inputs	$Q_{o,v}$	m^3/day	120,000
	$S_{o,v}$	mg/l	45
	TKN_v	mg/l	34
	TSS	mg/l	51
Primary clarifier	$Pr_{bl,BOD}$	%	30
	$Pr_{bl,SS}$	%	40
	Q_{bl}	m^3/day	-
Aerobic reactor	Temperature	°C	22
	SRT	day	5
	HRT	hour	5
	Q_w/Q_i	0.2	
Anaerobic digester	Temperature	°C	30
	SRT	day	20

Table 10. Output parameters of the on-site greenhouse gases emission of the Yen So wastewater treatment plant, Ha Noi

Result	Unit	Estimation value
Aerobic reactor		
$CO_{2,aerobic\ reactor}$	kg/day	8,539.09
$CO_{2,N2O\ emission}$	kg/day	4,830.72
Anaerobic digester		

$CO_{2,\ anaerobic\ digester}$	kg/ day	17. 29
$CO_{2\ equivalent}$	kg/day	147.22
Total on-site GHGs emission	kg/day	13,534.32
Total on-site GHGs emission	tons/day	4,490.03
Emission factor	$kgCO_{2-eq}$/kgBOD	2.506

4. Conclusions

In this research, the No.0 MTH model was applied for estimating the greenhouse gas emission from domestic wastewater treatment systems. The model was written by programing Scalable language and model formulations were based on equations of substrate and biomass, biochemical reactions and Monod kinetics equations for biological treatment reactors.

The No.0 MTH model was applied in calculating the greenhouse gas emissions of Yen So domestic wastewater treatment plant in HaNoi. Calculation results showed that amount of off-site greenhouse gas emissions 2 times higher than the amount of on-site greenhouse gas emissions and on-site greenhouse gas emission factor as 2,506 $kgCO_{2-eq}$ / kgBOD.

The No.0 MTH model can be applied to calculate the greenhouse gas emissions from domestic wastewater treatment systems with similar treatment method.

With variation of input parameters in the model, through the processes of calculating the model, will simulate the results of greenhouse gas emissions from domestic wastewater treatment systems. From these results, the operational and technological parameters could be chosen to reduce the greenhouse gas emission from these domestic wastewater treatment systems.

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