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Prediction of Methane Emissions from Domestic Waste and the Conversion of Electrical Energy in North Surabaya for Ten Years

I Made Satya Graha[1] and Mohammad Razif [2]

[1,2]*Departement of* Environmental Engineering, Faculty of Civil, Environment, Geo Engineering Institut Teknologi Sepuluh Nopember (ITS), 60111 Keputih, Sukolilo, Surabaya, Indonesia

Abstract: *Predictions for ten years of methane gas emissions in research are conducted on wastewater. To predict the emissions of methane gas ten years first calculated the level of methane gas emissions. Then made predictions to know the emissions of methane gas produced by domestic wastewater for the last ten years. This domestic wastewater from rusunawa. The calculation of methane gas emissions is carried out with reference to the method developed by IPCC 2006. For the processing of wastewater by population and having the appropriate parameters - parameters there. adjusted to the circumstances in the field. Based on calculations, household wastewater generates methane gas emissions in 2007 of 5648.75 kg*CH_4 */ year or 8610.91* m^3 */ year and continues to increase each year. The methane emission prediction result yields the equation* $y = 1538x^2 + 5836x + 16610$ *to predict methane gas emissions over the next ten years. While the conversion of electrical energy in 2007 amounted to 770.90 kWh and increased every year along with the increase in methane gas emissions. The prediction result of electrical energy yields the equation* $y = 137,7x^2 + 522x + 1487$ *to predict electric energy ten years ahead.*

Keywords: *Domestic Wastewater, Emission, Methane Gas, Septic Tank*

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) concluded that global warming is because of an increase in the gases due to human activities through the greenhouse effect (STATE-RUN). Explanation of the IPPC strengthened by Jimbo in one of his books explain that "an increase in the intensity of this STATE-RUN caused by the rising gases that cause the STATE", the gases that cause the STATE-including the water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), NO_2, ozone and CFCS (man-made gas).

The survey study of the environmental and Health Risks or Environmental Health Risk Assessment (EHRA) year 2010 92.15% of residents have a septic tank and 7.85% do not have on-site septic tanks. From these data it is known that the inhabitants of the city of Surabaya, many are using the IPAL as the site of its domestic wastewater treatment. An increasing number of residents in North Surabaya from waste disposal activity from domestic CH_4 emissions will improve so that the necessary steps predictions for a period of 10 years. This research was conducted to find out the gas emission prediction of CH_4 generated from its community by IPAL Surabaya northern part.

2. Materials and Methods

2.1. Calculation and Prediction of The Emission of Methane Gas

According to "Manual of organization of the National Greenhouse Gas Inventory, book II, Volume 4 which is the translation of IPCC. In the book mentions that there are three steps to calculate the emissions of methane gas. The first step is to determine the organic materials of domestic wastewater that can be degraded, the second step is to determine the emission factors for CH_4 for domestic wastewater and the third step is to calculate the CH_4 emission estimation of domestic wastewater [1].

Sector	Waste			
Category	Domestic Wastewater Treatment and Discharge			
Category Code	4D1			
Sheet	1 of 3 Estimation of Organically Degradable Material in Domestic Wastewater			
STEP 1				
	A	B	C	D
Region or City	Population	Degradable organic component	Correction factor for industrial BOD discharged in sewers	Organically degradable material in wastewater
	(P)	(BOD)	(I) 2	(TOW)
	cap	(kg BOD/cap.yr) 1		(kg BOD/yr)
				D = A x B x C
Indonesia	218,868,791	14.6	1	3,195,484,349
			Total	3,195,484,349

1 g BOD/cap.day x 0.001 x 365 = kg BOD/cap.yr
2 Correction factor for additional industrial BOD discharged into sewers, (for collected the default is 1.25, for uncollected the default is 1.00).

Fig. 1: Estimation of Organically Degradable Material Domestic Wastewater

Sector	Waste		
Category	Domestic Wastewater Treatment and Discharge		
Category Code	4D1		
Sheet	2 of 3 Estimation of CH_4 emission factor for Domestic Wastewater		
STEP 2			
	A	B	C
Type of treatment or discharge	Maximum methane producing capacity	Methane correction factor for each treatment system	Emission factor
	(B_0)	(MCF_j)	(EF_j)
	(kg CH_4/kgBOD)		(kg CH_4/kg BOD)
			C = A x B
Untreated System			
Sea, river, lake discharge	0.6	0.1	0.06
Stagnant sewer	0.6	0.5	0.3
Flowing sewer (open/closed)	0.6	0	0
Treated System			
centralized, aerobic treatment plant	0.6	0	0
centralized, aerobic treatment plant (not well managed)	0.6	0.3	0.18
Anaerobic digester for sludge	0.6	0.8	0.48
Anaerobic shallow lagoon	0.6	0.8	0.48
Anaerobic deep lagoon	0.6	0.2	0.12
Septic system	0.6	0.5	0.3
Latrine (dry climate, ground water table lower than latrine, small family 3-5 persons)	0.6	0.1	0.06
Latrine (dry climate, ground water table lower than latrine, communal)	0.6	0.5	0.3
Latrine (wet climate/flush water use, ground water table higher than latrine)	0.6	0.7	0.42
Latrine (regular sediment removal for fertilizer)	0.6	0.1	0.06

Fig. 2: Estimation of CH_4 Emission factor for Domestic Wastewater

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Sector	Waste
Category	Domestic Wastewater Treatment and Discharge
Category Code	4D1
Sheet	3 of 3 Estimation of CH_4 emissions from Domestic Wastewater

STEP 3									
		A	B	C	D	E	F	G	H
Income group	Type of treatment or discharge pathway	Fraction of population income group (U_i) (fraction)	Degree of utilization ($T_{i,j}$) (fraction)	Emission Factor (EF_j) (kg CH_4/kg BOD)	Organically degradable material in wastewater (TOW) (kg BOD/yr)	Sludge removed (S) (kg BOD/yr)	Methane recovered and flared (R) (kg CH_4/yr)	Net methane emissions (CH_4) (kg CH_4/yr)	Net methane emissions (CH_4) (Gg CH_4/yr)
				Sheet 2 of 3	Sheet 1 of 3			G = [(A x B x C) x (D -E)] - F	
Rural	Septic tank	0.54	0.11	0.30					
	Latrine	0.54	0.20	0.06					
	Other	0.54	0.35	0.06					
	Sewer	0.54	0.00	0.30					
	None	0.54	0.34	0.00					
Urban high income	Septic tank	0.12	0.88	0.30					
	Latrine	0.12	0.03	0.06					
	Other	0.12	0.05	0.06					
	Sewer	0.12	0.04	0.06					
	None	0.12	0.00	0.00					
Urban low income	Septic tank	0.34	0.80	0.30					
	Latrine	0.34	0.10	0.06					
	Other	0.34	0.07	0.06					
	Sewer	0.34	0.01	0.06					
	None	0.34	0.02	0.00					
							Total		

Fig. 3: Estimation of CH_4 Emission From Domestic Wastewater

2.2. Calculation and Prediction of Electric of Energy

Calculation of electric energy from methane gas (CH_4) can use the equations below. Where 1 Kg of methane gas equivalent to 6.13 x 10^7J, while 1 kWh is equivalent to 3.6 x 10^6J. For methane gas density is 0.656 kg/m3. While the 1 m^3 of methane gas equivalent to 11.17 kWh.

$$E = Vgm \times FK$$

Where, E is the production of electrical energy (kWh), Vgm is the amount of methane gas volume (m^3), and FK is Conversion Factor (kWh/m^3). And the conversion factor is 11.17 kWh/m^3. [4]

3. Results and Discussions

3.1. Methane Gas Emission

Calculation of methane gas emissions from domestic wastewater rusunawa is done based on the calculation of methane gas emissions from activities of non domestic calculation based on uncertain population non domestic activities as has been done previous research [3]. Population equivalent by dividing the consumption of drinking water per day with the use of rusunawa drinking water every home in North Surabaya and per person per day. The amount of drinking water consumption for each can be obtained from the use of rusunawa average drinking water through a field survey. Population equivalent and methane gas emissions resulting from household wastewater for 2007-2016 can be seen in table 1.

TABLE I: Data of Emission of Methane Gas

Year	Methane Gas Emission (Net) ($kg\ CH_4/yr$)	Methane Gas Emission (Net) ($Gg\ CH_4/yr$)	Methane Gas Emission (m^3/yr)
2007	5648.75	0.01	8610.91
2008	7580.92	0.01	11556.29
2009	10174.00	0.01	15509.14
2010	13654.03	0.01	20814.08
2011	18325.52	0.02	27935.25
2012	24593.81	0.02	37490.56
2013	33006.18	0.03	50314.29
2014	45515.47	0.05	69383.33
2015	46374.46	0.05	70692.78
2016	81985.79	0.08	124978.34

Calculation of the emission of methane gas by using the IPCC template can be seen in Figure 4 to 6. While the methane gas emission Prediction ten years can be seen in Figure 7.

Sector	Waste			
category	Domestic Wastewater Treatment and Discharge			
category code	4D1			
Sheet	1 of 3 estimation of Organically Degradable Material in Domestic			
STEP 1				
	A	B	C	D
Years	Population	Degradable organic component	Correction factor for industrial BOD discharged in sewers	Organically degradable material in wastewater
	(P)	(BOD)	(I)	(TOW)
	cap	(kg BOD/cap.yr)		(kg BOD/yr)
				D = A x B x C
2007	2151.60	14.6	1.25	39,267
2008	2887.56	14.6	1.25	52,698
2009	3875.26	14.6	1.25	70,723
2010	5200.80	14.6	1.25	94,915
2011	6980.16	14.6	1.25	127,388
2012	9367.74	14.6	1.25	170,961
2013	12572.00	14.6	1.25	229,439
2014	17336.77	14.6	1.25	316,396
2015	17663.96	14.6	1.25	322,367
2016	31228.26	14.6	1.25	569,916
			Total	1,994,070

Catatan: g BOD/cap.day x 0.001 x 365 = kg BOD/cap.yr

correction factor for additional industrial Bod discharged into sewers, (for collected the default is 1,25, for uncollected the default is 1,00)

Fig 4: Estimation of Organically Degradable Material Domestic Wastewater

Sector	Waste		
category	Domestic Wastewater Treatment and Discharge		
category code	4D1		
Sheet	2of 3 Estimation of CH4 emission factor for Domestic Wastewater		
STEP 2			
	A	B	C
Type of Treatment of discharge	Maximum methane producing capacity	Methane correction factor for each treatment system	Emission factor
	(B_0)	(MCF_j)	(EF_j)
	($kg\ CH_4/kgBOD$)		($kg\ CH_4/kg\ BOD$)
			C = A x B
Untrated System			
sea, river, lake discharge	0.6	0.1	0.06
stagnant sewer	0.6	0.5	0.3
flowing sewer (open/close)	0.6	0	0
Treated System			
centralized aerobic treatment plant	0.6	0	0
centralized aerobic treatment plant (not wellmanaged)	0.6	0.3	0.18
Anaerobic digester for sludge	0.6	0.8	0.48
anaerobic shallow lagoon	0.6	0.8	0.48
Anaerobic deep lagoon	0.6	0.2	0.12
Septic system	0.6	0.5	0.3
Latrine (dry climate, ground water table lower than latrine small family 3-5 persons)	0.6	0.1	0.06
Latrine (dry climate, ground water table lower than latrine, communal)	0.6	0.5	0.3
Latrine (wet climate/ flash water use, ground water table higher than latrine)	0.6	0.7	0.42
Latrine (regular sediment removal for fertizer)	0.6	0.1	0.06

Fig 5: Estimation of CH_4 Emission factor for Domestic Wastewater

YEARS 2007									
	SeCtor	Waste							
	Category	Domestic Wastewater Treatment and Discharge							
	category Code	4D1							
	Sheet	3 of 3 Estimation of CH_4 emissions from Domestic Wastewater							
STEP 3									
		A	B	C	D	E	F	G	H
Grup income	**Type of treatment or discharge pathway**	Fraction of population income group	Degree of utilization	Emisiion Factor	Organically degradable material in wastewater	Sludge removed	Methane recovered and flared	Net methane emissions	Net methane emissions
		(U_i)	(T_{ij})	(EF_j)	(TOW)	(S)	(R)	(CH_4)	(CH_4)
		(fraction)	(fraction)	(kg CH_4/kg BOD)	(kg BOD/yr)	(kg BOD/yr)	(kg CH_4/yr)	(kg CH_4/yr)	(Gg CH_4/yr)
				Sheet 2 of 3	Sheet 1 of 3			G = [(A x B x C) x (D -E)] - F	
Rural	Septic tank	0.12	0.00	0.30	39,267			-	-
	Latrine	0.12	0.00	0.18	39,267			-	-
	Other	0.12	0.00	0.06	39,267			-	-
	Sewer	0.12	0.00	0.30	39,267			-	-
	None	0.12	0.00	0.00	39,267			-	-
Urban high income	Septic tank	0.34	0.00	0.30	39,267			-	-
	Latrine	0.34	0.00	0.18	39,267			-	-
	Other	0.34	0.00	0.06	39,267			-	-
	Sewer	0.34	0.00	0.30	39,267			-	-
	None	0.34	0.00	0.00	39,267			-	-
Urban low income	Septic tank	0.54	0.86	0.30	39,267			5,471	0.0
	Latrine	0.54	0.00	0.06	39,267			-	-
	Other	0.54	0.14	0.06	39,267			178	0.0
	Sewer	0.54	0.00	0.30	39,267			-	-
	None	0.54	0.00	0.00	39,267			-	-
							Total	5,649	**0.006**

Fig 6: Estimation of CH_4 Emission From Domestic Wastewater

From Figure 4 using the population for ten years, 14.6 kg of degradation organic components based on previous research [2]. Correction factors for the industry, where if the correction factors enter the IPAL domestic then its worth 1.25 but if not then its value is 1. From real conditions because of waste and domestic accommodated at IPAL rusunawa, then correction factors is 1.25. Figure 5 shows the emission factors for methane gas for domestic IPAL comes from the multiplication between the maximum CH_4 production capacity (B0) in the kgCH4/kgBOD with correction factors methane gas for each processing system (MCFj). Where methane gas production capacity maximum (B0) and correction factors methane (CH_4) gas for each treatment system is the regulation of the IPCC. While Figure 6 shows the calculation of the emission of methane gas that affects a number of aspects, so that the emission of methane gas will be produced in the year 2007 of 5,649 kgCH_4/yr to convert to the unit m^3/yr, methane gas emissions results were split with the density of methane gas. Where the density is 0.006 kg/m^3 [2].

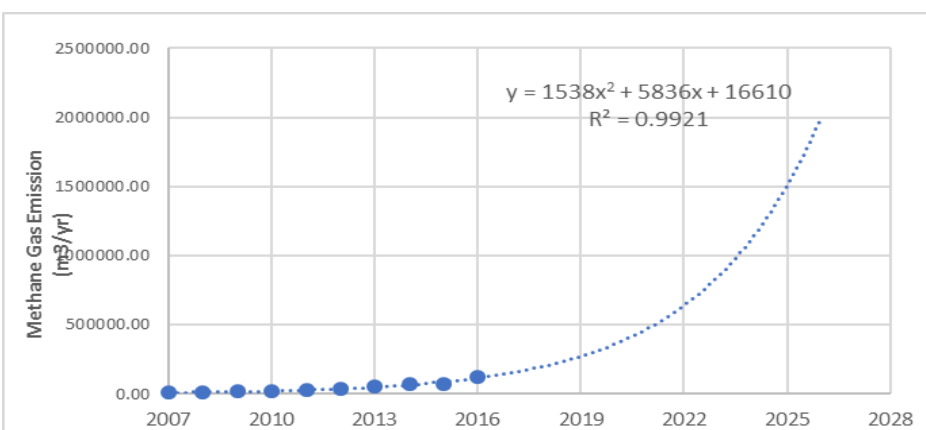

Fig. 7: Prediction of Ten Years Metane Gas Emission

The Figure 7 that based on the results of the prediction for ten years, methane gas emissions will increase each year. Predictions of increased methane gas emissions per year from the year 2017 to 2026 can be seen with the equation Y = 1538x + 5836x + 16610. The increase in the emission of methane gas in line with the increase in population. The increasing population rises, it would further go up also the emission of methane gas produced. This result is supported by previous research in South of Surabaya. Methane gas emissions shows the increase each year for ten years [2]

3.2. Electric Energy

Calculation of the electrical energy generated from methane gas emissions of domestic wastewater using the equation E = Vgm x FK. Where E is the energy of electricity generated (kWh), Vgm is the emission of methane gas produced and FK is methane gas conversion factor into electrical energy. Where 1 m^3 of methane gas equal to 11.17 kWh [4]. Then the results of calculation of electrical energy conversion in East Surabaya from year 2007 until 2016 can be seen in table 2. Prediction of electric energy produced during the past ten years can be seen in Figure 8.

TABLE II: Electrical Energy Conversion Results

Year	Methane Gas Emission (m^3/yr)	Electric Energy (kWh/yr)
2007	8610.91	770.90
2008	11556.29	1034.58
2009	15509.14	1388.46
2010	20814.08	1863.39
2011	27935.25	2500.92
2012	37490.56	3356.36
2013	50314.29	4504.41
2014	69383.33	6211.58
2015	70692.78	6328.81
2016	124978.34	11188.75

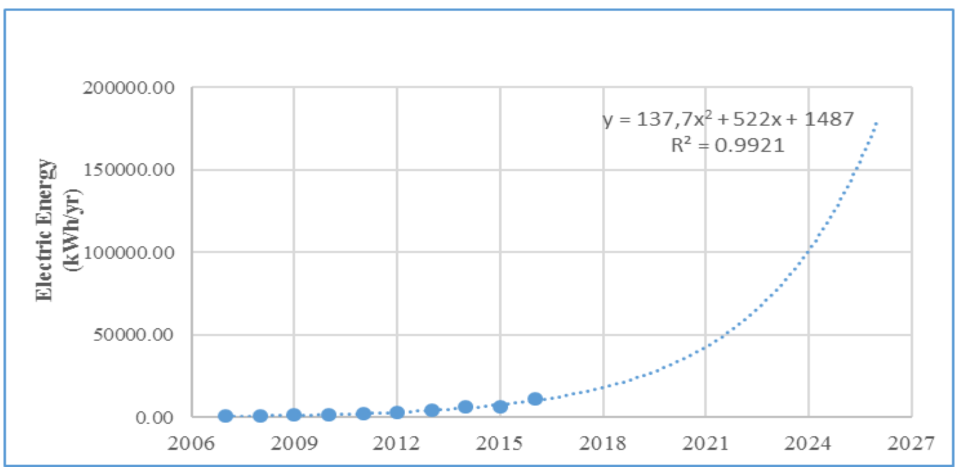

Fig. 8: Prediction of Ten Years Electric Energy Conversion

Figure 8 that based on the results of the prediction for ten years, the potential energy of electricity will increase every year. Predictions of rising potential of electric energy per year from the year 2017 to 2026 can be seen with the equation Y = 137, $7x^2$ + 522x + 1487. Increase the potential of electric energy in line with the increase in population as well as the emission of methane gas. The rising population will go up also the emission of methane gas generated by the potential of electric energy shows the increase each year for ten years [1].

4. Conclusion

The methane emission prediction result yields the equation y = 1538x2 + 5836x + 16610 to predict methane gas emissions over the next ten years. While the conversion of electrical energy in 2007 amounted to 770.90

kWh and increased every year along with the increase in methane gas emissions. The prediction result of electrical energy yields the equation y = 137,7x2 + 522x + 1487 to predict electric energy ten years ahead.

5. References

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