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Qualitative Assessment of Methane Generation Potential from Municipal Solid Wastes: A Case Study

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Abstract: This research covered the estimation of methane emitted from solid wastes using Ilorin, Central Nigeria, as a case study from 1991-2020. The 1991 Nigerian National population figure was used as baseline. The estimation was carried out by the application of the model equations of default methodology established by the Intergovernmental Panel on Climate Change (IPCC). The estimated amount of methane emitted in 1991 was found to be approximately 2.61 Gg CH_4 and is expected to be 5.85 Gg CH_4 by 2020. The estimated amount of methane was found to be increasing yearly. It was concluded that methane could be generated from solid waste disposal sites.

Key words: Emission, methane, greenhouse gas, infrared radiation, anthropogenic

INTRODUCTION

Numerous chemicals found in the earth's atmosphere act as greenhouse gases because while they tend to be transparent to sunlight that is radiated primarily in the visible and ultraviolet spectra, they absorb infrared radiation (heat). This heat is radiated back into the earth's atmosphere from the earth's surface. This process traps the heat from sunlight at, or close to, the earth's surface and gradually raises the temperature of the planet. In addition, high temperature tends to melt the ice in the atmosphere and thereby increasing the volume of water on the earth that may result into hurricane as seen in the U.S.

Most of the gases that occur naturally in the atmosphere, including water vapour, carbon dioxide (CO_2), methane, nitrous oxide and a number of halogenated substances, exhibit these 'greenhouse' properties. Other gases have so-called 'indirect effects' on global warming because they may contribute to the build-up or decomposition of other greenhouse gases (GHGs) in the atmosphere e.g., carbon monoxide (CO). Of the GHGs, CO_2 is the main contributor to anthropogenic radiative forcing because of changes in concentrations from pre-industrial times. According to Houghton *et al.* (1996), well-mixed GHGs (CO_2, CH_4, N_2O and the halocarbons) induced additional radiative forcing of around 2.5 W m^{-2} on a global and annually averaged basis.

Atmospheric concentrations of several important greenhouse gases have been increasing for many years. This growth in concentrations of greenhouse gases is believed to be caused by human activities, including burning of fossil fuels, industrial processes, livestock rearing, agriculture and waste disposal.

Disposal and treatment of municipal and industrial wastes can produce emissions of several greenhouse gases. The most significant greenhouse gas produced in this source category is methane. It is estimated that approximately 5-20% of global anthropogenic methane produced and released into the atmosphere is a by-product of the anaerobic decomposition of waste. A significant source of this type of methane production is solid waste disposal in land fills, where methanogenic bacteria break down organic matter in the waste under anaerobic conditions to produce methane.

There has been significant increase in MSW generation in Nigeria during the last few decades and their management has become a major issue because of poor management practice. This poor practice has underlined the need to study the ever-increasing contribution of SW to the global GHG effect.

The Intergovernmental Panel on Climate Change (IPCC), together with the Organization for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA), have developed guidelines which provide a default methodology for estimating, reporting and verifying national greenhouse gases inventory data.

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This aim of this work is to assess, in quantitative terms, the amount of methane that can be obtained from solid waste disposal sites in Ilorin, the administrative capital of Kwara State, Nigeria. It has a population of 572, 178 by the 1991 census. Presently the population is estimated to be 794,000 using an annual population growth rate of 2.38% for Nigeria.

Literature review

Methane: The most significant greenhouse gas produced in the disposal and treatment of municipal and industrial solid waste is methane. It is a colourless, odourless gas with a wide distribution in nature. It is a principal compound of natural gas. It is a mixture containing about 75% CH_4, 15% ethane (C_2H_6) and 5% other hydrocarbons, such as propane (C_3H_8) and butane (C_4H_{10}). It is the simplest hydrocarbon and is a significant fuel. Burning one molecule of methane in the presence of oxygen releases one molecule of carbon dioxide (CO_2) and 2 molecules of water.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

At room temperature, methane is a gas less dense than air it melts at -183°C and boils at -164°C. It is non-toxic when inhaled but it can produce suffocation by reducing the concentration of oxygen inhaled. It is synthesised commercially by the distillation of bituminous coal and by heating a mixture of carbon and hydrogen.

$$C + 2H_2 \rightarrow CH_4$$

It can be produced in the laboratory by heating sodium acetate with sodium hydroxide and by the reaction of carbide with water.

$$Na + NaOH \rightarrow Na + CH_4$$

$$Al_4C_3 + 6H_2O \rightarrow 3CH_4 + 2H_2O_3$$

The reaction of methane with chlorine and fluorine are triggered by light. When exposed to bright visible light, mixtures of methane with chlorine or fluorine react explosively. The principal use of methane is as fuel. The combustion of methane is highly exothermic.

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)} \quad \Delta H = -891\text{kJ}$$

The global atmospheric concentration of methane has increased from a pre-industrial value of 715-1732 ppb in the early 1990s and is 1774 ppb in 2005 (IPCC, 2007). Eleven of the last 12 years (1995-2006) rank among the twelve warmest years in the instrument record of global surface temperature (since 1850). The updated 100-year linear trend (1906-2005) of 0.74 (0.56- 0.92)°C is therefore, larger than the corresponding trend for 1901-2000 of 0.6 (0.4-0.8)°C. The linear warming trend over the last 50 years (0.13[0.10-0.16]°C per decade) is nearly twice for the last 100 years. The total temperature increase from 1850-1899 to 2001-2005 is 0.76 (0.57- 0.95)°C (IPCC, 2007).

Methane is one of the principal greenhouse gases, second after carbon dioxide in its contribution to global warming. Methane is responsible for roughly 18% of the total contribution in 1990 of all greenhouse gases. On a kilogram for kilogram basis, methane is more a potent greenhouse gas than carbon dioxide (about 21% times greater over a 100-year time frame (IPCC, 2001). Atmospheric concentrations of methane have been increasing at about 0.6% per year (Steele *et al*., 1992) and have more than doubled over the last two centuries (IPCC, 1990).

Reductions in methane emissions will produce substantial benefits in the short run. Methane has a shorter atmospheric lifetime has other greenhouse gases-methane lasts around 11 years in the atmosphere whereas carbon dioxide lasts about 120 years (IPCC, 1992). Due to methane's high potency and short atmosphere lifetime, stabilisation of methane emissions will have an immediate impact on mitigating climate change. The unique characteristics of methane emissions make methane recovery one of the most attractive and efficient ways to mitigate climate change (PNNL, 2004).

Anthropogenic CH_4 emissions in the year 1990 are estimated at 375±75 Mt CH_4 in the second IPCC assessment (Prather *et al*., 1995). They arise from a variety of activities, dominated by biologic processes, each associated with considerable uncertainty.

Since, methane is a source of energy as well as a greenhouse gas, reducing methane emission from solid waste disposal sites is economically beneficial. Methane emission reduction strategies offer one of the most effective means of mitigating global warming in the short term.

Ilorin waste composition: The waste composition of the city of Ilorin as given by CEC (2002) is presented in Table 1.

Theories for calculation: Six different modelling approaches have been used to generate greenhouse gas emission scenarios. These six models are representative of the approaches to emissions scenario modelling and

Table 1: 2002 Ilorin waste composition

Waste composition	Percentages	Approximate values
Food waste	70.18	70
Paper	5.89	6
Plastics	7.99	8
Metals	2.41	2.5
Glass, Bottles, Ceramics	2.47	2.5
Textiles	1.30	11.3
Leather	0.78	
Rubber	0.09	
Wood	0.08	
Aluminium	0.02	
Miscellaneous	8.85	
Total	100.00	

Source: (CEC, 2002)

the different integrated assessment frameworks used in the scenario literature and include both macro-economic (so-called top-down) and systems-engineering (so-called bottom-up) models. The 6 modelling approaches include:

- Asian Pacific Integrated Model (AIM) from the National Institute of Environmental Studies in Japan (Morita *et al*., 1994).
- Atmospheric Stabilization Framework Model (ASF) from ICF Consulting in the USA (Lashof and Tirpak, 1990; Pepper *et al*., 1998; Sankovski *et al*., 2000).
- Integrated Model to Assess the Greenhouse Effect (IMAGE) from the National Institute for Public Health and Environmental Hygiene (RIVM) (Alcamo *et al*., 1998; de Vries *et al*., 1994, 1999, 2001), used in connection with the Dutch Bureau for Economic Policy Analysis (CPB) WorldScan model, the Netherlands.
- Multiregional Approach for Resource and Industry Allocation (MARIA) from the Science University of Tokyo in Japan (Mori and Takahashi, 1999; Mori, 2000).
- Model for Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE) from the International Institute of Applied Systems Analysis (IIASA) in Austria (Messner and Strubegger, 1995; Riahi and Roehrl, 2000).
- Mini Climate Assessment Model (MiniCAM) from the Pacific Northwest National Laboratory (PNNL) in the USA (Edmonds *et al*., 1994, 1996a, b).

There have been several models for the assessment of potential methane generation from municipal solid waste. These models include the default methodology model (IPCC Tier I), the first order decay (FOD) model (IPCC Tier II) and the triangular model. The default methodology has been applied by some authors (El-Fade and Massoud, 2000; MfE, 2004). Mor *et al*., (2006) applied the first order decay model while Kumar *et al*. (2004) used both the default methodology and the triangular model.

The main difference between these methods is that the first order decay model gives a time-dependent methane emissions profile that better reflects the true pattern of degradation process over time whereas the default model is based on the assumption that all potential methane is released in the year of waste disposal (IPCC, 2000).

The 'Good Practice Guidance' (IPCC, 2000) also suggests the 2 methods. The use of the first order decay model requires historical data on quantities of solid waste disposed of in solid waste disposal sites, its composition and management practices for the last several decades. The default model is used when such data are unavailable.

Since historical data for this study is not available, the default methodology was used in the analysis.

MATERIALS AND METHODS

The baseline emission estimate used was the IPCC (1996) Tier 1 methodology. Tier 1 methodology is a mass balance approach that involves estimating the degradable organic carbon (DOC) content of the solid waste (i.e., the organic carbon that is accessible to biochemical decomposition) and using this estimate to calculate the amount of methane that can be generated by the waste. The steps involved included:

- Estimate total municipal solid waste generated and disposed of in SWDSs.
- Determine methane correction factors (MCF).
- Estimate methane production rate per unit of waste.
- Estimate total net annual methane emissions.

There are has established model equations for each of these steps (IPCC, 1996). Excel spreadsheet was used in the calculations.

RESULTS AND DISCUSSION

The result showed that there is increase in solid waste generation and this has resulted in an increase in methane emissions from the landfills (Table 2). The 1991 population of Ilorin City, which was 572,178 is also expected to rise to 1, 285, 306 by 2020. The quantity for 1991 was 89.9 Gg/MSW. By keeping municipal solid waste (MSW) generation rate and the fraction of MSW to

Table 2: Quantity of municipal solid waste disposed of in solid waste disposal sites using country data (Default model)

Year	A	B (kg/capita/day)	C	D	E (Gg/MSW) E = C*D
1991	572178.000	0.43	89.8033371	1	89.8033371
1992	588370.637	0.43	92.3447715	1	92.3447715
1993	605021.526	0.43	94.9581286	1	94.9581286
1994	622143.636	0.43	97.6454436	1	97.6454436
1995	639750.301	0.43	100.4088097	1	100.4088097
1996	657855.234	0.43	103.2503790	1	103.2503790
1997	676472.537	0.43	106.1723647	1	106.1723647
1998	695616.710	0.43	109.1770426	1	109.1770426
1999	715302.663	0.43	112.2667529	1	112.2667529
2000	735545.728	0.43	115.4439020	1	115.4439020
2001	756361.672	0.43	118.7109645	1	118.7109645
2002	777766.708	0.43	122.0704848	1	122.0704848
2003	799777.505	0.43	125.5250795	1	125.5250795
2004	822411.209	0.43	129.0774392	1	129.0774392
2005	845685.446	0.43	132.7303308	1	132.7303308
2006	869618.344	0.43	136.4865991	1	136.4865991
2007	894228.543	0.43	140.3491699	1	140.3491699
2008	919535.211	0.43	144.3210514	1	144.3210514
2009	945558.058	0.43	148.4053371	1	148.4053371
2010	972317.351	0.43	152.6052082	1	152.6052082
2011	999833.932	0.43	156.9239356	1	156.9239356
2012	1028129.23	0.43	161.3648829	1	161.3648829
2013	1057225.29	0.43	165.9315091	1	165.9315091
2014	1087144.76	0.43	170.6273708	1	170.6273708
2015	1117910.96	0.43	175.4561254	1	175.4561254
2016	1149547.84	0.43	180.4215338	1	180.4215338
2017	1182080.05	0.43	185.5274632	1	185.5274632
2018	1215532.91	0.43	190.7778904	1	190.7778904
2019	1249932.49	0.43	196.1769047	1	196.1769047
2020	1285305.58	0.43	201.7287111	1	201.7287111

Table 3: Methane emissions from solid waste disposal with existing system (Default model)

Year	A	B	C	D	E	F	G = C*D*E*F	H = B*G	J = H*A	K	L (GgCH4) L = J*K
1991	89.80333710	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	4.34293092	0.6	2.605758550
1992	92.34477154	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	4.46583586	0.6	2.679501517
1993	94.95812857	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	4.59221902	0.6	2.755331410
1994	97.64544361	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	4.72217881	0.6	2.833307288
1995	100.4088097	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	4.85581647	0.6	2.913489885
1996	103.2503790	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	4.99323608	0.6	2.995941648
1997	106.1723647	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	5.13454466	0.6	3.080726797
1998	109.1770426	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	5.27985228	0.6	3.167911366
1999	112.2667529	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	5.42927210	0.6	3.257563257
2000	115.4439020	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	5.58292050	0.6	3.349752297
2001	118.7109645	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	5.74091715	0.6	3.444550287
2002	122.0704848	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	5.90338510	0.6	3.542031060
2003	125.5250795	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	6.07045090	0.6	3.642270539
2004	129.0774392	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	6.24224466	0.6	3.745346796
2005	132.7303308	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	6.41890018	0.6	3.851340110
2006	136.4865991	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	6.60055506	0.6	3.960333035
2007	140.3491699	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	6.78735077	0.6	4.072410460
2008	144.3210514	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	6.97943279	0.6	4.187659676
2009	148.4053371	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	7.17695074	0.6	4.306170445
2010	152.6052082	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	7.38005845	0.6	4.428035069
2011	156.9239356	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	7.58891410	0.6	4.553348461
2012	161.3648829	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	7.80368037	0.6	4.682208222
2013	165.9315091	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	8.02452453	0.6	4.814714715
2014	170.6273708	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	8.25161857	0.6	4.950971142
2015	175.4561254	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	8.48513937	0.6	5.091083625
2016	180.4215338	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	8.72526882	0.6	5.235161291
2017	185.5274632	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	8.97219393	0.6	5.383316356
2018	190.7778904	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	9.22610701	0.6	5.535664209
2019	196.1769047	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	9.48720584	0.6	5.692323506
2020	201.7287111	0.95	0.153	0.5	0.5	1.33	0.05090575	0.048360463	9.75569377	0.6	5.853416261

SWDS constant, annual MSW generated is expected to rise to 201.73 Gg/MSW by the year 2020 based on the projected annual population growth rate of 2.83% and per capita waste generation of 0.43 kg/person/day. This will be mainly due to the increase in the quantity of degradable organic compounds (DOCs) that will be produced and deposited into the landfills. Therefore, as the population increases, annual municipal solid waste (MSW) generated increases along side with the total annual MSW disposed to SWDS while MSW generation rate and fraction of MSW to SWDS were kept constant. Also, it was found that the fraction of MSW to SWDS had no effect in the calculation because the value of annual MSW generated and total annual MSW disposed to SWDS in a particular year were the same.

Methane emission from solid waste disposal with existing system is shown in Table 3. The 1991 emission was estimated as 2.61 Gg and this value is expected to rise to 5.89 Gg by the year 2020 (about twice the 1991 level). Unfortunately, there is no landfill gas control system that could have reduced the net emission. The immediate implementation of this control system will lead to an improvement in waste management policy and boost the principle of sustainable development. Source segregation of municipal solid waste, followed by recycling and composting/anaerobic digestion will lower the net methane emission considerably. The recycling option reduces the methane emissions from landfills due to diversion of waste. Apart from the reduction in the global warming potential, recycling also contributes to resource conservation. Nigeria has a high potential for recycling since large proportion of the waste currently going to landfills is actually recyclable. High emission implies high global warming potential. When averaged over 100 years, each kilogram of methane warms the earth 25 times as much as the same amount of carbon dioxide (http://en.wikipedia.org/wiki/Methane).

The methane emission reduction from SWDS rose from 1.56 Gg in 1991and is expected to be 3.51 by the year 2020 (Table 4). It has been reported that a 20% reduction in human methane emissions from current levels would prevent an estimated 370,000 premature deaths worldwide between the years 2010 and 2030, including 30,000 deaths in 2030. Methane contributes globally to the formation of ozone that has dual effects: ozone protects against the sun's harmful ultraviolet rays high up in the atmosphere, but it is a pollutant at ground level where it can aggravate respiratory and cardiovascular problems (http://www.pricetom.edu/main/news/archive/514/36/49E93/index.xm/?section=newrelease). Reducing methane emissions is good for slowing global climate change, but it is also good for improving ozone air quality.

Table 4: Methane emission reduction from solid waste disposal sites (Default model)

Year	A(Gg/MSW)	B	C	D	E	F	G =C*D*E*F	H =B *G	J = H*A	K	($GgCH_4$) L=J –K	M	($GgCH_4$) N = L*M
1991	89.80333710	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	4.342930916	2.60575855	1.737172366	0.9	1.563455130
1992	92.34477154	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	4.465835861	2.67950152	1.786334344	0.9	1.607700910
1993	94.95812857	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	4.592219016	2.75533141	1.836887606	0.9	1.653198846
1994	97.64544361	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	4.722178814	2.83330729	1.888871526	0.9	1.699984373
1995	100.4088097	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	4.855816475	2.91348988	1.942326590	0.9	1.748093931
1996	103.2503790	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	4.993236081	2.99594165	1.997294432	0.9	1.797564989
1997	106.1723647	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	5.134544662	3.08072680	2.053817865	0.9	1.848436078
1998	109.1770426	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	5.279852276	3.16791137	2.111940910	0.9	1.900746819
1999	112.2667529	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	5.429272095	3.25756326	2.171708838	0.9	1.954537954
2000	115.4439020	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	5.582920496	3.34975230	2.233168198	0.9	2.009851378
2001	118.7109645	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	5.740917146	3.44455029	2.296366858	0.9	2.066730172
2002	122.0704848	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	5.903385101	3.54203106	2.361354040	0.9	2.125218636
2003	125.5250795	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	6.070450899	3.64227054	2.428180360	0.9	2.185362324
2004	129.0774392	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	6.242244660	3.74534680	2.496897864	0.9	2.247208077
2005	132.7303308	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	6.418900183	3.85134011	2.567560073	0.9	2.310804066
2006	136.4865991	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	6.600555059	3.96033304	2.640222023	0.9	2.376199821
2007	140.3491699	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	6.787350767	4.07241046	2.714940307	0.9	2.443446276
2008	144.3210514	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	6.979432794	4.18765968	2.791773117	0.9	2.512595806
2009	148.4053371	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	7.176950742	4.30617044	2.870780297	0.9	2.583702267
2010	152.6052082	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	7.380058448	4.42803507	2.952023379	0.9	2.656821041
2011	156.9239356	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	7.588914102	4.55334846	3.035565641	0.9	2.732009077
2012	161.3648829	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	7.803680371	4.68220822	3.121472148	0.9	2.809324933
2013	165.9315091	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	8.024524525	4.81471472	3.209809810	0.9	2.888828829
2014	170.6273708	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	8.251618569	4.95097114	3.300647428	0.9	2.970582685
2015	175.4561254	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	8.485139375	5.09108362	3.394055750	0.9	3.054650175
2016	180.4215338	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	8.725268819	5.23516129	3.490107528	0.9	3.141096775
2017	185.5274632	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	8.972193927	5.38331636	3.588877571	0.9	3.229989814
2018	190.7778904	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	9.226107015	5.53566421	3.690442806	0.9	3.321398525
2019	196.1769047	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	9.487205843	5.69232351	3.794882337	0.9	3.415394104
2020	201.7287111	0.95	0.153	0.5	0.5	1.3	0.05090575	0.0483605	9.755693769	5.85341626	3.902277507	0.9	3.512049757

CONCLUSION

Emission of methane, a greenhouse gas from solid waste disposal site, has been demonstrated to be feasible and useful using the Default Methodology Model Equations Tier 1) established by the Intergovernmental Panel on Climate Change via Excel programming language.

From the estimation of net annual methane emissions, it can be observed that the higher the population, the higher total annual MSW disposed to SWDSS, the higher the Gross annual methane generation, the higher the estimate recovery methane per year, the higher the net annual methane generation and the higher the net annual methane emissions.

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