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Preliminary Study of Short-Lived Climate Pollutants (SLCPs) Emissions from Waste Management in the Commune of Lomé Golfe 3 in Togo

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Abstract: Short-lived climate pollutants (SLCPs) are air pollutants and Greenhouse Gas (GHG) responsible for air pollution and climate change. They have a costly impact on health and the environment. Waste management activities are one of the sources of emissions of these pollutants. This Master's thesis falls within this theme. The categorization of sources of SLCPs in the municipality of Lomé Golfe 3 is carried out in accordance with the methodology based on the 2006 IPCC guidelines. This study shows that the main SLCPs emitted by the waste sector are methane (CH_4) and black carbon (BC). These pollutants in the municipality come from three subcategories, the most important of which is "the incineration and open burning of waste" with an emission of 12.792 Gg CO_2-eq in 2019 to 13.848 Gg CO_2-eq in 2021. Then comes "the treatment and discharge of wastewater" with an emission of 4.76 Gg CO_2-eq in 2019 to 5.88 Gg CO_2-eq in 2021; and finally, the sub-category "Solid waste disposal" with an emission of 3.136 Gg CO_2-eq in 2019 to 6.664 Gg CO_2-eq in 2021. From these results we deduce that the emissions of SLCPs increase during years and it depends on the population growth and the amount of waste it generates per year. To finish, the solution approaches such as: the prohibition of burning waste, the capture of landfill gas, the diversion of waste via composting, are suggested in order to reduce the emissions of these pollutants.

Keywords: Short-Lived Climate Pollutants, Waste, Air Quality, Togo

1. Introduction

Climate's elements are degenerating due to Greenhouse Gas (GHG) emissions and Short-Lived Air and Climate Pollutants (SLCPs) leading to global warming [1]. IPCC, in its 5th report, reveals that in 2011 total cumulative emissions exceeded 531 gigatons and that a 10% reduction in global emissions per decade would be the solution to keeping global temperature below 2°C [2]. At the same time, the release of pollutants into the atmosphere has multiple consequences, including chronic diseases such as lung cancer and cardiovascular disease [1]. According to the World Health Organization (WHO) report in 2012, more than 3.3 million people die prematurely due to indoor air pollution and 2.6 million due to outdoor pollution [3]. To address the challenges of global warming and pollution, the United Nations Framework Convention on Climate Change (UNFCCC) and the Climate and Clean Air Coalition were established to stabilize atmospheric concentrations of GHGs and reduce Short-Lived Climate Pollutants (SLCPs) that affect the climate, respectively [4]. As a party to the UNFCCC, Togo also joined the Climate and Clean Air Coalition (CCAC) on 26 March 2014 and adopted its SCCP reduction plan on 24th January 2019 [5]. As the waste sector is one of the potential sources of emissions [5], this work is being conducted to bring out the preliminary SLCPs emissions of the Commune of Golfe 3 with the objective of proposing waste management measures for an environmentally friendly trajectory. With an area of about 17 km^2 and an estimated population of 124,000 in 2019, the

Commune is growing at a rate of 2.69%. It was chosen for the study because it is representative of urban municipalities facing waste management problems.

2. Methodology

2.1. Data Collection Method

Data collection started with the literature review on waste management ([6, 7]) in the said commune. The qualitative and quantitative data sought concerned the pre-collection, collection and disposal of waste, except for recycling, which is not taken into account. The aim was to map the various sources of SLCPs emissions linked to waste management. The gases targeted are Black Carbon (BC) emitted to the atmosphere in the form of Particulate Matter (PM) from the incomplete combustion of fossil fuels, biofuels and biomass [8] methane from oil and gas systems, landfills and wastewater treatment [9], hydrofluorocarbons from refrigeration and air conditioning, and ozone as a secondary pollutant.

2.2. Estimating Method

Emissions calculation is based on the IPCC 2006 guidelines ([10, 11]) with the Model Waste Template. With IPCC Tier 1 methodology, due to the fact that the available data is not disaggregated and not representative enough of the municipality and the total absence of own Emission Factors (EF), the algorithm combines Activity Data (AD) with EFs (Equation 1).

$$\text{Emission (i)} = \sum_{\text{j,k}} DA\text{(j,k)*EF(i,j,k)} \quad (1)$$

With:
DA = Activity Data;
EF = Emission Factor;
i = Type of gas;
j = Management technology;
k = Sub-category of activity.

2.2.1. Methane Emissions from Solid Waste Landfill Sites

Methane emissions from Solid Waste Landfill Sites (SWLS) are given by Equation 2.

$$\text{Emission } CH_4 = \left[\sum CH_4\, Product_{x,T} - R_T\right].\left(1 - OX_T\right) \quad (2)$$

With:
Emission CH_4 = CH_4 emitted in year T in kt;
T = Inventory year;
x = Category or type/material of waste;
RT = CH_4 recovered in year T, kt;
OXT = Oxidation factor of year T, (fraction).

2.2.2. Open Burning of Solid Waste

For open burning of solid waste, the emissions are calculated with Equation 3.

$$\text{Emission } CH_4 = \text{Iw. EF. } 10^{-6} \quad (3)$$

With:
CH_4 emissions = CH_4 emissions in the year, kt/year;
Iw = volume of waste burnt in the open, kt/year;
EF = aggregation factor for CH_4 emissions, kg CH_4 /kt waste.

2.2.3. Black Carbon Emissions from Open Burning

Black Carbon emissions from open burning are given by Equation 4.

$$\text{Emission BC} = \text{DA. FE. } 10^{-6} \quad (4)$$

With:
BC emissions = BC emissions in the year, kt/year;
DA = volume of solid waste aggregate incinerated or burnt in the open, t/year;
EF = gas emission factor, kg/t waste;
10^{-6} = conversion factor from kilogram to kt.

2.2.4. Domestic Wastewater Discharge

CH_4 emissions from the domestic wastewater discharge are calculated with Equation 5.

$$\text{Emission } CH_4 = \sum_{\text{i,j}}\left(\text{Ui } T_{\text{ij}}.\, EF_{\text{J}}\right)(\text{TOW} - \text{S}) - \text{R} \quad (5)$$

With:
CH_4 emissions = CH_4 emissions of the year, kg CH_4 / year;
TOW = Total organic matter in wastewater in the inventory year, kg BOD/yea;
S = Organic component removed as sludge in the inventory year, kg BOD/year;
Ui = Fraction of population by income group i in the inventory year;
Tij = Degree of use of the treatment and/or disposal route or system, j, for each revenue group fraction, i, in the inventory year;
i = Income class: rural, high income urban and low income urban;
j = Each treatment and/or disposal route or system;
EFj = Emission factor, kg CH_4 /kg BOD;
R = volume of CH_4 recovered in the inventory year, kg CH_4 /year.

2.2.5. Assumptions

Three (03) assumptions were formulated concerning:

a) Solid waste disposal: The best available activity data on waste production is that related to the population averaged over the population of Greater Lomé;
b) Incineration and open burning of waste: Emissions from waste combustion are summarize as emissions from open burning; and
c) Wastewater treatment and discharge: Biological Oxygen Demand (BOD) is estimated without industrial wastewater.

3. Results and Discussion

3.1. Results

3.1.1. Data Collection Results

The collection included IPCC default emission factors and parameters from the IPCC Emission Factor Database (IPCC

EFDB) and socio-economic data (Table 1), municipal solid waste generation (Table 2), waste composition (Table 3), amount of waste landfilled (Table 4) and amount of waste burnt in the open air (Table 5).

Table 1. *Social and economic data.*

Year	Population	GDP (109 U$$)
2019	124,000	7.22
2020	127,336	7.575
2021	130,761	8.4

Table 2. *Waste generation.*

Year	Population	Waste generation Ratio (Kg/day/inhabitant)	Quantity of waste produced (Tonnes)
2019	124	0.56	25,345.6
2020	127,336	0.56	26,027.5
2021	130,761	0.56	26,727.5

Table 3. *Waste composition.*

Category of waste	Percentage
Food	10.4
Garden Waste	14
Disposable diapers	0.5
Paper	7
Wood	4.9
Textiles	5.3
Plastic	7
Rubber and Leather	3
Other	47.8

Table 4. *Landfill.*

Year	Fraction of DSM deposited on site (%)	Quantity of MSW buried (Tonnes)
2019	91	23,064.5
2020	91	23,684.1
2021	91	24,322

Table 5. *Activity data on burnt waste.*

Year	Population	Number of people incinerating waste (P*Pfrac)	Total volume of MSW burned (Tonne/year)
2019	124,000	11,160	691
2020	127,336	11,460	710
2021	130,761	11,768	715

3.1.2. SLCPs Evaluation Results

The results of the aggregated emissions by gas and by category of methane (CH_4) and Black Carbon (BC) emissions for the years 2019, 2020 and 2021 are presented in Table 6.

Table 6. *Aggregate emissions of SLCPs from the waste sector in Gulf 3.*

Source categories	Types of pollutants	Quantity (kt CO_2-eq)		
		2019	2020	2021
Solid waste disposal	CH_4	3.136	4.916	6.664
	Subtotal	3.136	4.916	6.664
Open burning of waste	CH_4	1.792	1.848	2.016
	BC	11	12	12
	Subtotal	12.792	13.848	13.848
Wastewater treatment and discharge	CH_4	avr.76	05.juin	mai.88
	Subtotal	avr.76	05.juin	mai.88
	Total	20.688	24.364	26.392

These emissions are divided into categories (1) solid waste disposal, (2) open burning of waste and (3) domestic wastewater discharge (Table 7).

Table 7. *Emissions by category and trend.*

	CH_4 Waste disposal	CH_4 Burning of waste	BC Burning of waste	CH_4 Wastewater discharge
2019	3.136	1.792	11	avr.76
2020	4.956	1.848	12	05.juin
2021	6.664	2.016	12	mai.88

The results obtained are based on the assumptions made, activity data and parameters contained in Tables 1, 2, 3, 4, and 5.

3.2. Analysis and Discussion

3.2.1. Aggregate Emissions of SLCPs and Trend

Aggregate emissions estimated for 2019, 2020 and 2021 are 20.688, 24.364 and 26.392 kt CO_2 -eq respectively, indicating a growth with an average annual rate of 13.76% without taking into account the emissions attributable to the management of solid biomedical waste and small industrial units in the municipality. The trend is presented in Figure 1 combined with the cumulative emissions of the three (03) years estimated at 71.44 kt CO_2 -eq.

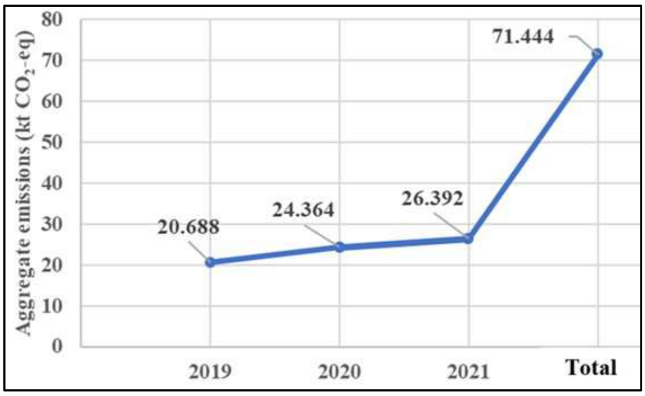

Figure 1. *Aggregate emissions trends of SLCPS.*

This growth can be explained by population growth, which is a key driver of waste generation. Considering the base year 2019, the total emissions of SLCPs from the waste sector (Figure 2) indicate that open burning (62%) is the main source followed by wastewater treatment and solid waste disposal in the proportions of 23% and 25%.

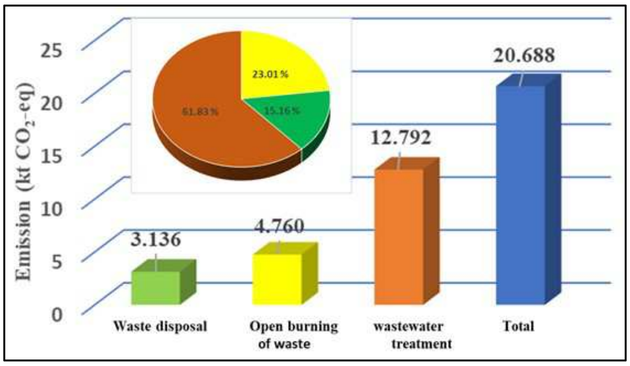

Figure 2. *SLCPs issuance by category in 2019.*

In 2019, BC and CH_4 emissions are in the proportions of 57% and 43% respectively.

3.2.2. Emissions by Category and Trend

Emissions by category and trends of CH_4 and BC in the three categories are provided in Figure 3. CH_4 emissions from household solid waste disposal will continue to grow with the ever-increasing population with an average annual rate of 56.25% while in the open burning category the rate would be 6.25% for methane and 4.55% for black carbon. Wastewater discharge in the Gulf 3 municipality will increase with an average annual rate of 11.76% if nothing is done.

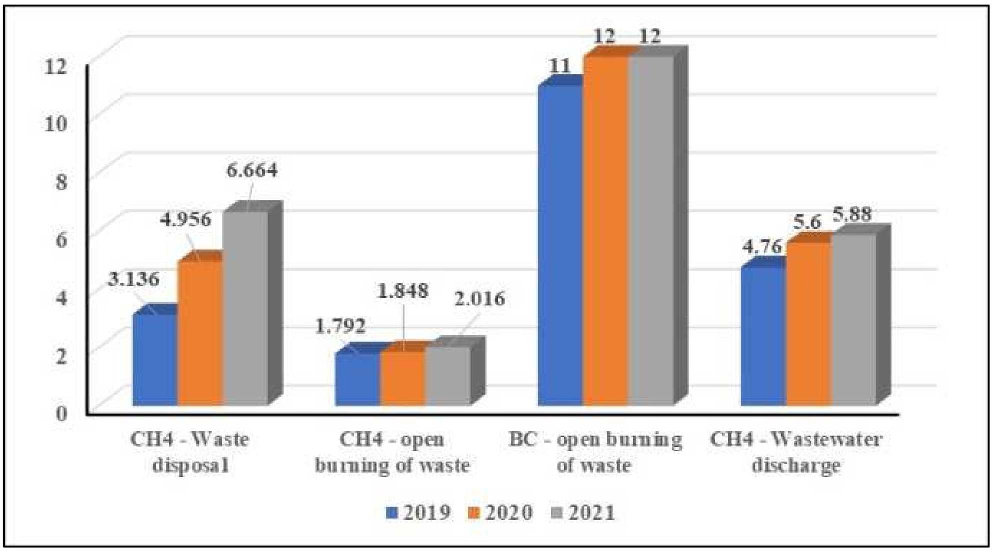

Figure 3. *Emissions by category and trends.*

3.2.3. Results Discussion for Approaches to Reduce SLCPs

The challenges related to waste management in cities in developing countries are enormous as is the case in the city of Lomé. The majority of the inhabitants of these countries consider waste as useless and therefore throw it anywhere without thinking of its repercussions in the near future [12]. Solid waste management in the city of Lomé [13] and in particular in the Commune of Golfe 3 is deficient and constitutes a serious threat to public health [14], the environment and socio-economic development. Despite the efforts made by the municipal authorities, waste is either scattered on the spot or burnt by the inhabitants, or transported to uncontrolled dumps, or used as fill in flood-prone areas or left on public roads and empty spaces. Removal from intermediate dumps and transfer to landfill is entrusted to private companies which suffer from serious malfunctions due to lack of human, material and financial resources. Consequently, inadequate waste management practices produce SLCPs which are not only pollutants but also GHG with a high potential for global warming. In the Commune of Golfe, waste management accumulates SLCPs emissions of about 20.688 CO_2-eq, 24.3464 CO_2-eq and 26.392 CO_2-eq respectively for the years 2019, 2020 and 2021 on the basis of the hypotheses formulated and the data collected.

The most worrying source of BC emissions remains the open burning of waste. Indeed, according to surveys conducted by the technical service of the commune of Lomé Golfe 3 in 2018, 9% of the population burn waste in the yard and in wild dumps, thus causing emissions of particulate matter into the atmosphere. In addition, due to insufficient sanitation efforts, domestic wastewater disposal is done through autonomous systems composed of traditional or improved latrines and septic tanks, causing increased methane emissions in the domestic wastewater treatment and discharge category. Solid waste disposal is also a major source of methane emissions due to the large amount of biodegradable material contained in the waste.

To remedy this [15], institutional, organizational, technical, financial and behavioral constraints must be addressed. For the Commune, this means:

1) To seek financial resources to meet the needs of waste management;
2) Enforce laws and texts on waste management in Togo;
3) Coordinate the actions of stakeholders in the waste management sector;
4) Provide appropriate sites in the Commune to house intermediate dumpsites to facilitate pre-collection at household level;
5) Revalue the salary of pre-collectors in order to improve their performance;
6) Training staff to ensure that their skills are appropriate; and
7) Raise awareness of the harmful effects of burning household waste on human health and the climate.

4. Conclusion

Waste management in Lomé Golfe 3 contributes to the emission of SLCPs into the atmosphere, resulting in pollution and global warming. In 2019, methane (CH_4) and black carbon (BC) emissions are estimated at 9.632 kt CO_2-eq and 11 kt CO_2-eq respectively, and the trend over three years indicates an upward trend with an annual average rate of 13.76%. Although default parameters are applied on the basis of the assumptions made, the results obtained are an indicator of the risks of real pollution and of the reinforcement of the natural greenhouse effect. The current fight against climate change, which is supported by the Paris Agreements and which aims to keep the increase in average global temperature below 1.5°C, requires community action in all sectors of socio-economic activity. Therefore, the communes of Togo and in particular the Commune of Golfe 3 should take measures to limit the emissions of SLCPs in the waste sector. The aim is to develop a waste management system and improve air quality for the well-being of the population and the environment. Composting and recycling of waste, capture of landfill gas and banning open burning of waste are opportunities to be seized.

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