

RESEARCH ARTICLE

(Open Access)**Estimation of methane emission from solid waste landfill in Prizren**AFRIM BERISHA¹, TAFE VESELAJ^{1*}, FATBARDH SALLAKU²¹Kosovo Environmental Protection Agency, Str. Luan Haredinaj, Government Building Rilindja, XV/04, 10000 Prishtina, Kosovo²Agriculture University of Tirana – Faculty of Agriculture and Environment, Republic of Albania

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Abstract

The paper presents an estimation of methane emissions from the deposited municipal solid waste in Landovica sanitary landfill, starting from 2006 to 2016 and the projection of methane emissions for 2017-2022. Methane emissions were calculated according to the empirical calculation methodology based on Intergovernmental Panel on Climate Change (IPCC 2006) recommendation, using default values and country specific conditions. In addition to methane emissions, the following parameters were evaluated: population covered by the waste service collection in the area of research, climate conditions for the region, amount of landfilled waste, landfill characteristics, and composition of disposal waste. The landfill was established in 2006, with a total surface of about 20 ha and actual waste deposition area of the size of about 6 ha. According to the analysis of waste in the Prizren region, the main fractions of waste composition are organic waste of about 37 %, paper and cardboard waste of about 13%. The yearly amount of deposited waste in the sanitary landfill, in Landovica has amounted to about 93,101 tons in 2016, and overall, to about 632,100 tons of waste deposited in the period from 2006 to 2016. Based on these parameters, the total amount of methane emitted from the landfill during 2006–2016 was estimated at 15.6 Gg or 390 Gg CO₂ equivalents. The total mass of methane emitted for the time period of 2017–2022 is projected to be 25.7 Gg, or 642 Gg CO₂ equivalents.

Keywords: solid waste; landfill; methane emission; climate change.**1. Introduction**

Urbanization and increase of the urban population indicate an increasing amount of solid waste landfilling. One of the major impacts of waste disposal including either sanitary landfills or open dump sites is the emissions of greenhouse gases, mainly methane, to the atmosphere. These greenhouse gases are produced from biodegradation of waste under anaerobic conditions through microbial activities. When waste is landfilled, the organic fraction in the waste, materials such as food and garden residues, textiles and paper, slowly decomposes.

In this process, landfill gas is formed. CH₄ emission from landfills is continually increasing owing to increasing population growth and per capita waste generation, with landfills ranking as the third-largest anthropogenic CH₄ source [1, 12]. Landfill gas emission from municipal solid waste landfills plays a significant role causing global climate changes. These waste disposal sites are considered as one of the most important anthropogenic sources of greenhouse gases, especially methane gas, which has a global warming potential that is 25 times greater than that of carbon dioxide [2, 3].

Before 2000, most of the solid waste collected from urban areas in Kosovo was deposited in unmanaged landfills or waste dump sites. During the past decade (2006-2016), there was an improvement of waste disposal practice from open dumping and unmanaged landfills to sanitary managed landfills. This improvement of waste management increased the amount of waste disposed. At present, about 60% of the solid waste is disposed in the sanitary landfills, 20% in open unmanaged dump sites, while 5% are recycled [4, 7]. The GHG emissions from waste management in Kosovo represent around 4% of the total GHG national emissions. Methane emissions from managed municipal solid waste landfills are major source of GHG emissions from the waste sector in Kosovo [8, 9, 13].

2. Material and Methods

2.1. Characteristics of the Landfill

The sanitary landfill of Solid Waste Management for Prizren region is situated in Landovica. This landfill serves for depositing of the waste collected from the following municipalities: Prizren, Suhareka, Malishevo, Mamush and Rahovec. In addition, from begin of the year 2010 the waste mass from Gjakovo was transported to Prizren landfill. Actual population covered by the waste collection service in the region represents 75%, (or 347,208 inhabitants) of population of the region (table 1), [11].

Table 1. Population (%) covered by the waste collection service in Prizren region (11)

Name of Regional sanitary landfill	Region	Municipalities	Area of municipality km ²	Nr. of population	% of population covered by the waste collection service	Nr. of population covered by the waste collection service
Sanitary landfill in Landovica	Prizren Region	Prizren	627	186986	90 %	168287
		Suhareka	361	59681	74 %	44164
		Gjakova	587	94543	63 %	59562
		Malisheva	306	57301	70 %	40110
		Rahovec	276	58908	55 %	32399
		Mamushe	11	5839	46 %	2686
Total			2168	463258	75 %	347208

Landfill in the Prizren Region was established in 2006. The construction of the landfill was financed by the European Union funds as well. The waste depositing process in the sanitary landfill started in 2006. The total surface of the landfill is about 20 ha. The waste landfilling area has a size of about 6 ha. At present, the maximal of waste height layer is about 20 m at the pit bottom zone but it is very different in the different filling sections. The expected live span of landfill is 15 years. The waste deposition shall be continued up to the year 2021. The characteristics of the sanitary landfill in Landovica are presented in table table 2.

Table 2. Characteristics of the sanitary landfill in Landovica [4]

Starting year of operation	Type of landfill	Status of landfill	Area of landfill	Waste deposition area	Maximal height of waste	Total deposited waste until 2016 tons	Waste deposition is planned up to the year
2006	Managed Semi-anaerobic	Current use	20 ha	6 ha	20 m	632,100	2021

2.1. Climate Conditions Prevailing in the Prizren Region

Landovica landfill is located in Prizren region, which is characterized with 700 mm/yr rainfall. There are more moderate temperature conditions but cold days cannot be excluded. The coolest months are December and January. The Figure 1 shows the historical data on climate conditions in Prizren Region.

2.3. Quantification of CH₄ emission

Calculation of CH₄ emission from the landfill in Landovica was based on data on the landfilled waste for the interval 2006–2016. The estimation of the CH₄ emission from the landfill was carried out by means of empirical calculation according to the IPCC recommendations [2].

The IPCC default method for estimation of methane emission from waste disposal sites is based on the following equation:

$$\text{Methane emissions} = (\text{MSWT} * \text{MSWF} * \text{MCF} * \text{DOC} * \text{DOCF} * \text{F} * 16/12 - \text{R}) * (1 - \text{OX})$$

Where:

MSWT = Total amount of generated waste (Gg/year)

MSWF = Fraction of disposed waste

MCF = Correction factor of waste fraction that generates methane gas for the sanitary landfill.

DOC = Fraction of biodegradable organic carbon

DOCF = Fraction of biodegradable organic carbon that is readily available for degradation

F = Fraction of methane in biogas.

OX = Fraction of methane gas that is oxidized to carbon dioxide.

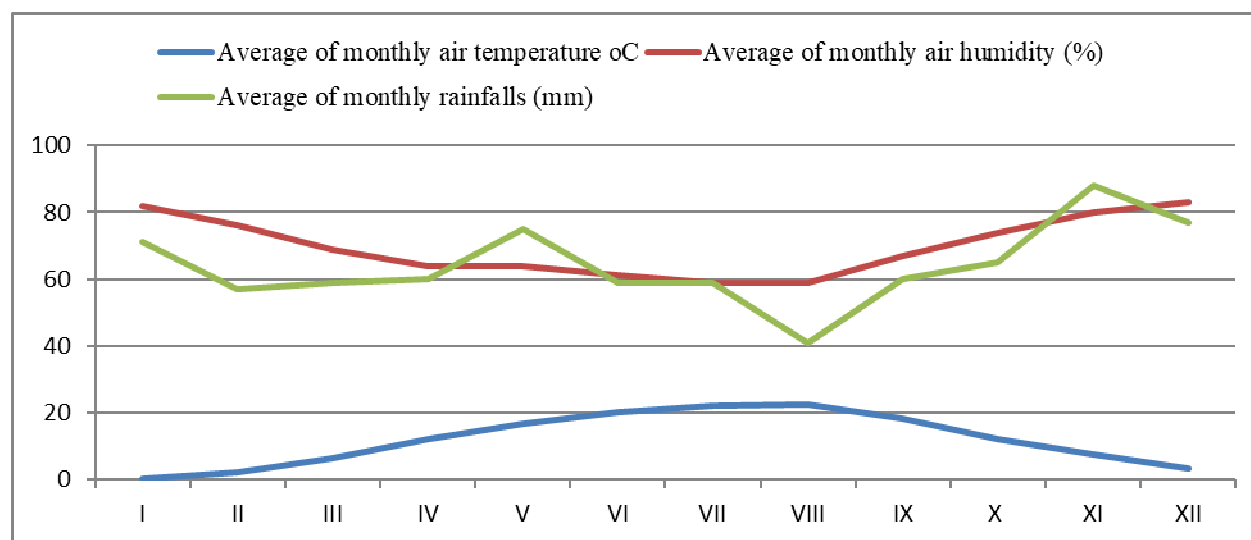


Figure 1. Climate conditions for the Prizren Region, historical data [6]

To perform the emission calculations over the years 2006–2016, annual data on waste disposal and the fractions of waste deposited into the sanitary landfills were collected from the Kosovo Environmental Protection Agency and the Statistical Agency of Kosovo and then entered into the IPCC 2006 model spreadsheet, as described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The specific parameters and values according to IPCC method applied for estimation of CH₄ emissions from Landovica landfill are presented in table 3. The projected emissions for the years 2017-2022 were calculated based on the projected waste disposal into the sanitary landfills and the projected population growth.

Table 3. Specific parameters according to IPCC 2006 default value used for the sanitary landfill in Prizren

Parameters		Value
DOC (Degradable organic carbon) (weight fraction, wet basis) Waste by composition	Food waste	0.15
	Garden	0.2
	Paper	0.4
	Wood and straw	0.43
	Textiles	0.24
	Disposable nappies	0.24
DOCF (fraction of DOC dissimilated)		0.5
Methane generation rate constant (k) (years ⁻¹)	Food waste	0.185
	Garden	0.1
	Paper	0.06
	Wood and straw	0.03
	Textiles	0.06
Wet temperate	Disposable nappies	0.1
Delay time (months)		6
Fraction of methane (F) in developed gas		0.5
Conversion factor, C to CH ₄		1.33

Oxidation factor (OX)	0
Methane Correction Factor (MCF) for managed semi-anaerobic landfills	0.5

3. Results and Discussion

3.1. Disposal of wastes

The yearly amount of deposited waste in the sanitary landfill in Landovica amounted about 93,101 tons in 2016. In total, about 632,100 tons of waste was deposited in the period 2006-2016 up to the year 2016. Detailed information on the waste disposals to the sanitary landfill in Landovica for the time period 2006-2016 are presented in the table 5.

Table 5. Waste disposal in the sanitary landfill in Landovica 2006-2016 [4, 7]

Nr.	Year	Waste disposal per year/tons	Disposed waste from year to year/tons
1.	2006	40,000	40,000
2.	2007	41,200	81,200
3.	2008	42,436	123,636
4.	2009	43,709	167,345
5.	2010	55,000	222,345
6.	2011	56,650	278,995
7.	2012	58,350	337,345
8.	2013	60,100	397,445
9.	2014	61,903	459,348
10.	2015	79,661	539,009
11.	2016	93,101	632,100

3.2. Waste Composition in Prizren Region

According to analysis of waste composition performed for the municipalities of the region, it is characterized by a higher content of organic waste fractions. The main fractions of waste composition are food waste accounting for 37 % and paper and cardboard accounting for 13% [5, 10]. Solid waste composition referring to the Prizren region is presented in figure 2.

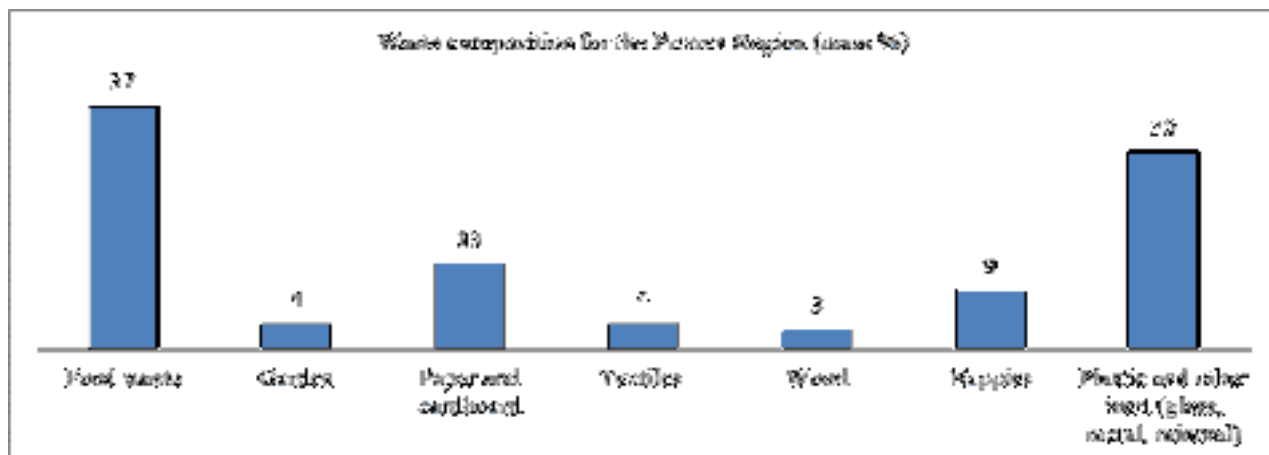


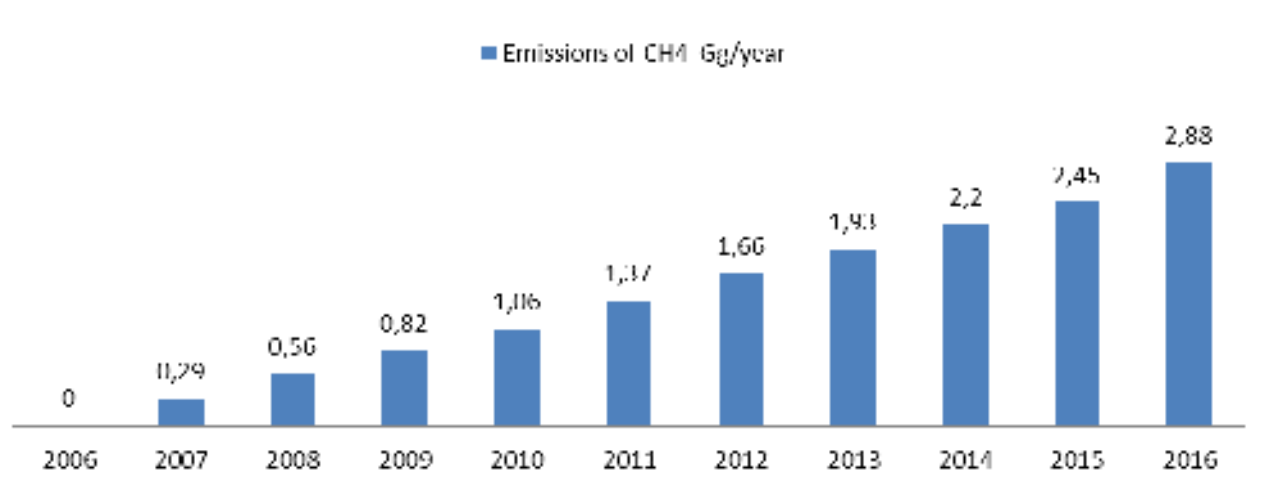
Figure 2. Waste composition in Prizren Region

3.3. Calculation of CH₄ emission

Calculations of the CH₄ emissions from the sanitary landfill in Landovica, during 2006–2016 are presented in table 6 and figure 3. The total mass of CH₄ generated in the landfill during 2006–2016 amounted to 15.6 Gg or 390 Gg CO₂ eq.

Table 6. CH₄ emissions from the sanitary landfill in Landovica 2006-2016

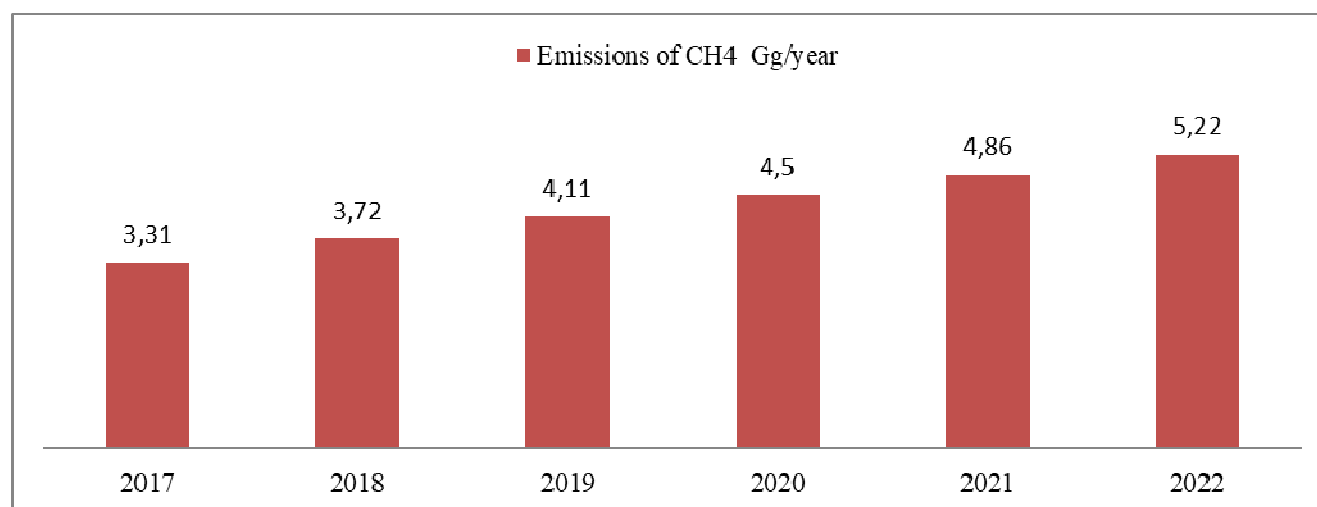
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Emissions CH ₄ tons/year	0	290	560	820	1060	1370	1660	1930	2200	2450	2880
Emissions CH ₄ Gg/year	0	0.29	0.56	0.82	1.06	1.37	1.66	1.93	2.20	2.45	2.88
Emissions CO ₂ eq Gg/year	0	7	14	20	26	34	42	48	55	61	72


Figure 3. CH₄ emissions from the sanitary landfill in Landovica 2006-2016 Gg/yr

The calculations of the projections of CH₄ emissions from the landfilled waste for the years 2017–2022 are presented in table 7 and figure 4. The total mass of CH₄ for the time period 2017–2022 was projected to be 25.7 Gg, or 642 Gg CO₂ eq.

Table 7. Projections of CH₄ emissions from the sanitary landfill in Landovica 2017-2022

Year	2017	2018	2019	2020	2021	2022
Emissions CH ₄ tons/year	3310	3720	4110	4500	4860	5220
Emissions of CH ₄ Gg/year	3.31	3.72	4.11	4.50	4.86	5.22
Emissions CO ₂ eq Gg/year	83	93	103	113	122	131


Figure 5. Projections of CH₄ emissions from the sanitary landfill Landovica 2017-2022 Gg/yr

4. Conclusions

- One of the major impacts from waste disposal are the emissions of greenhouse gases, mainly methane, to the atmosphere.
- At present, about 60% of solid waste in Kosovo is being disposed to sanitary landfills.
- Managed semi-anaerobic sanitary landfill of solid waste for Prizren Region, situated in Landovica is one of them.
- Landfill was established in 2006, with total surface about 20 ha, actual waste deposition area size of about 6 ha and lifespan expected for 15 years.
- Landovica landfill is located in Prizren region which is characterized with 700 mm/yr of rainfalls.
- Yearly amount of deposited waste in the sanitary landfill in Landovica was with about 116,529 tons in 2016, and all together about 985,207 tons of waste deposited from 2006-2016.
- According to analysis of waste for Prizren region the main fractions of waste compositions are food waste with 37 % and paper and cardboard with 13%.
- Estimation of CH₄ emission from the landfill in Landovica from the interval 2006–2016, has been carried out by means of empirical calculation according to the IPCC recommendations.
- Total mass of CH₄ generated in the landfill during 2006–2016 amounted to 15.6 Gg, or 390 Gg CO₂ eq.
- Total mass of CH₄ for time period 2017–2022 was projected to be 25.7 Gg, or 642 Gg CO₂ eq.

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