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Determination of Methane Explosion Level in the Velekince Municipal Solid Waste

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ABSTRACT
Management of the sanitary landfills represents one of the main challenges of the waste sector in Kosovo. At present, around 70% of the waste is disposed in sanitary landfills under semi-anaerobic conditions without gas collections. Non-adequate management of the sanitary landfills is a common practice of the waste management in the country. The paper presents determination of the explosion level of the methane in the Velekince municipal solid waste sanitary landfill. The methane concentration measurements from three different passive degassing wells of the landfill during the four months period (June-October 2017) were performed by using a portable combustible gas meter 8800B. In contrast to the degassing point (well 2) where maximal concentration of 29,200 ppm corresponding to 58.4% of low explosion level for methane was recorded, degassing point (well 3) showed a minimal concentration of 2.700 ppm and 5.4% of low explosion level, speaking for various waste structure distribution and phase of biodegradation of the deposited material. The results recorded show that the concentration of methane is within the lower explosive limits. Control measures and installing a ventilation system in the landfill are recommended.

Keywords: explosion level, methane, waste, landfill, monitoring.

INTRODUCTION

Urbanization, rapid economic growth, improvement in community living standards and lifestyle changes of the urban population result in increased generation of solid municipal waste (Darban Astane, *et. al.,* 2017). Before 2000, the waste services from urban areas in Kosovo were not developed and most of the solid waste was deposited at unmanaged landfills. During the last two decades, the waste disposal infrastructure has improved. Waste management in sanitary landfills has increased, while unmanaged landfills and open dumping have been reduced. This improvement in waste collection service has led to increased amounts of waste disposed in landfills. However, the waste collection, separation, recycling and disposal infrastructure is not yet sufficient to serve the entire Kosovo territory. At present, about 70% of total solid waste is disposed in sanitary landfills (Veselaj, et al., 2014). As in other countries of the world, the waste disposal sites in Kosovo are considered as common anthropogenic sources of methane (Scheutz, et al., 2009). Landfills are ranking as the third-largest CH_4 source (Ritzkowski, *et al*. 2007). The CH_4 emissions from managed landfills account for 1.8% of total European Union GHG emissions. The GHG emissions from waste management in Kosovo represent around 4% of the total GHG national emissions (Berisha, et al., 2015; UNDP Kosovo, 2012). The biodegradation of these wastes deposited lead to the evolution of landfill gases, with high risk of explosion (Huseyin, et al., 2018). This study was conducted during 2017, in the Velekince sanitary landfill in Gjilan.

MATERIAL AND METHODS

Study area

The Velekince landfill, situated in the Gjilan Region with geographical coordinates x=0540771 and y=4697970 (Fig. 1). the waste from the municipalities: Gjilan, Kamenica, Viti, Novoberdo, Partesh, Ranillug, Hani Elezit, Kaçanik, Shtime, Ferizaj and Shterpce is deposited in the Velekince sanitary landfill. Total population in the region is 352.554 inhabitants, where only 50% are covered by the waste collection service (MLGA, 2017).

The landfill was established in 2003. The waste landfilling process started in 2006. The landfill has a total area of about 25 ha, while the current landfilling area is about 6.5 ha. The landfill is expected to be used for the landfilling of the waste until 2025 (KEPA, 2015; GIZ, 2015). The landfill does not have an active degassing system installed. Some passive degassing wells are installed in the waste disposal area. The Gjilan region is characterized by a prevailing continental climate with 700 mm/yr of rainfalls and with yearly air temperature of about 10.8 degrees Celsius (KHMI, 2018). The data on the climate conditions of the Gjilan Region for the years 2006-2017 are presented in Figure 2.

The yearly amount of waste deposited in the landfill of Velekince, as well as the total amounted deposited waste for the years 2006-2016 are in Table 1.

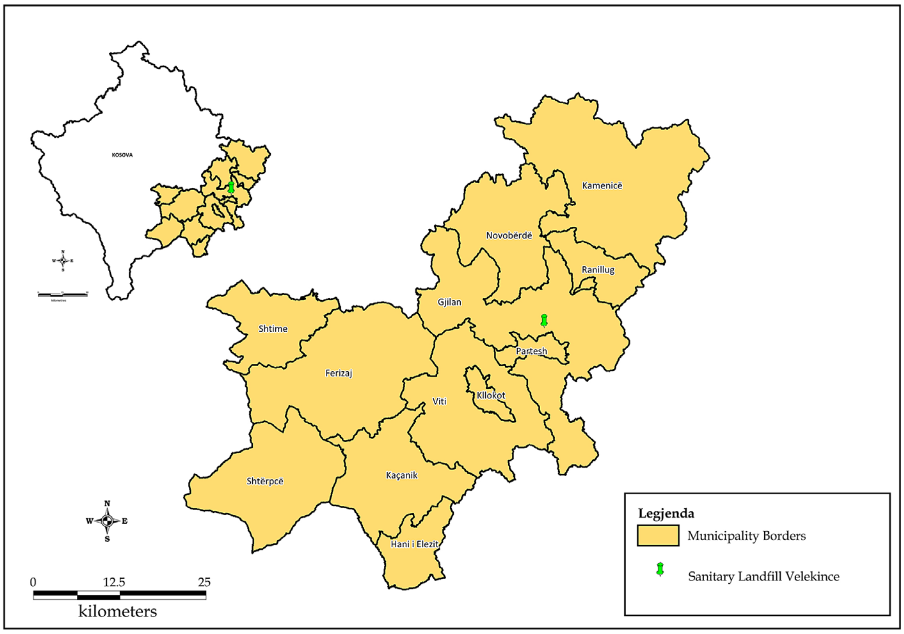

Figure 1. Map of the study area

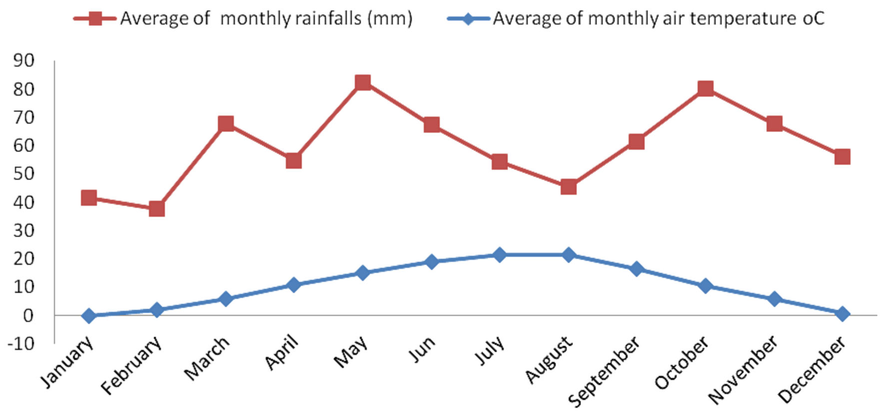

Figure 2. Climate conditions in the Gjilan Region 2006-2017 (KHMI, 2018)

Table 1. Waste disposal in the sanitary landfill in Velekinca 2006-2016 (Berisha, et al., 2015; KSA, 2017)

No.	Year	Waste disposal per year/tons	Accumulative waste disposed (tons)
1.	2006	29,200	29,200
2.	2007	29,930	59,130
3.	2008	30,678	89,808
4.	2009	31,445	121,253
5.	2010	32,231	153,484
6.	2011	33,037	186,521
7.	2012	33,863	220,384
8.	2013	34,710	255,094
9.	2014	35,557	290,651
10.	2015	38,245	328,896
11.	2016	52,955	381,851

Figure 3 shows the solid waste composition for the Gjilan Region. The main fractions of waste composition are food waste accounting for 40% and paper and cardboard accounting for 12% (MESP, 2017).

In-situ measurements of the CH_4 concentration

Currently, there is a wide variety of combustible gas and gas specific monitoring equipment available for LFG concentration,

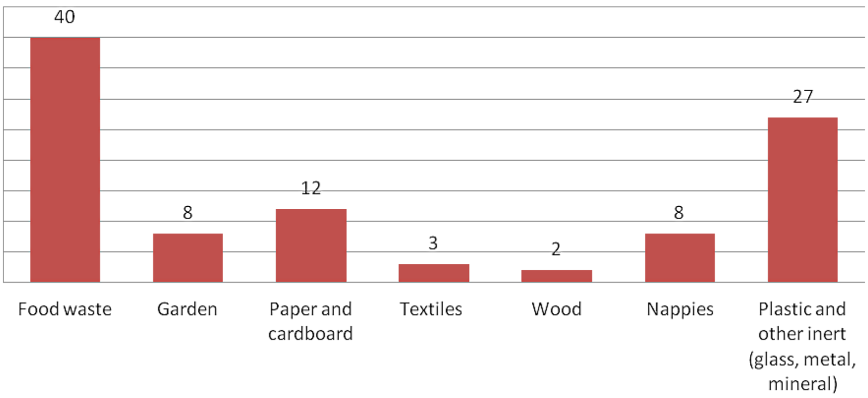

Figure 3. Waste composition in the Gjilan Region (%) (MESP, 2017)

Figure 4. Portable combustible gas meter 8800B

featuring a broad range of precision (MPCA, 2011). Measurement of the methane emissions from degassing wells from sanitary landfill Velekince was realized with Portable Combustible Gas Meter 8800B (Fig. 4, Table 2).

Table 2. Technical parameters of combustible gas meter 8800B (Gas Meter 8800B Manual, 2016)

Parameters	Description
Sensor	Catalytic combustion type
Detection gas	Combustible gas
Temperature measurement	Ambient temperature
Display unit	Combustible gas:% LEL; Temperature:°C
Range	0~100% LEL, Temperature: -15~50°C
Resolution	Combustible gas:1% LEL, Temperature:0.1°C/0.1°F
Accuracy	Combustible gas:±5F.S; Temperature:±1.5°C
Response time	90<60 Seconds
Alarm	Sound and light vibration alarm
Operation temperature	+15 – +50 °C

This piece of equipment registers and display units in LEL (Lower explosive limit). The unit % LEL was converted to ppm (parts per million) based on the values 100% LEL = 5% methane and 5% methane = 50,000 ppm methane (Kroes, 2016). The methane explosive limits and methane flammability range is presented in the Table 3 and Figure 5.

The measurements were carried out in three different degassing wells of the landfill, installed in the depositing area of the landfill during the time period July-October 2017. Figure 6 shows the positions in the landfill where measurements were conducted. In each of the degassing wells, at least 5 measurements and the average of the measurements for each of the wells were recorded.

RESULTS AND DISCUSSION

Measurements of the CH_4 concentration from the passive degassing wells in the municipal solid waste landfill in Velekince during June-October 2017 are presented in Figure 7, showing that the methane concentration is different in different parts

Table 3. Methane explosive limits and flammable range (Matheson, 2001)

Methane concentration			Methane flammability range
0–100% Lower Explosive Limit/LEL	0 – 50,000 ppm	0 – 5% CH_4 by volume	Lean
5–15% Upper Explosive Limit/UEL	50,000 – 150,000 ppm	5 – 15% CH_4 by volume	Explosive
15–100% GAS	150,000 – 1,000,000 ppm	15 – 100% CH_4 by volume	Rich

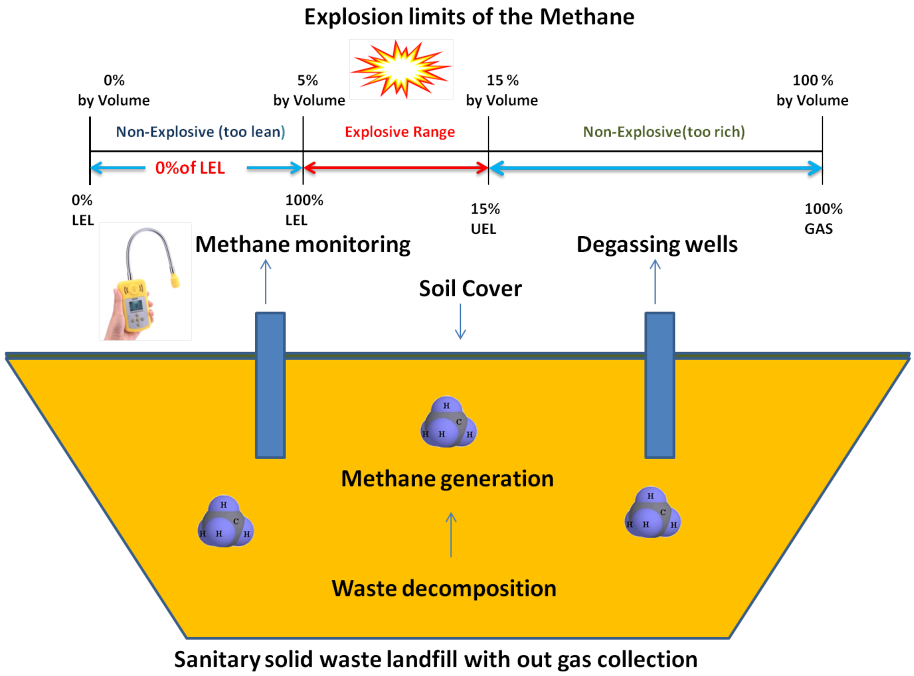

Figure 5. The methane concentration monitoring scheme in a landfill without gas collection

of the landfill, depending on the depth of waste layer height in the landfilling area, the position of the degassing well, and the anaerobic phase of decomposition of the organic waste. The maximal concentration of methane was recorded in the degassing well 2 in July with 29,200 ppm corresponding to 58.4% of LEL, and the minimal concentration of the methane was recorded in the degassing well 3 in October with 2.700 ppm and 5.4% of LEL with evident seasonal variation (higher concentration in summer period).

Figure 6. Monitoring sites of methane concentration in the sanitary landfill Velekince

Methane in the landfill is generated as a result of bacterial decomposition of organic waste. The amount of organic waste deposited dictate the amount and concentration of methane in the landfill (Kumar, et al., 2004; Mutasem El-Fadel, et al., 2002). The results recorded from the measurements at the degassing wells of landfills show that the concentration of methane is within the lower explosive limits. Seasonal variations, in the decreasing of the concentration of the methane in the sanitary landfill studied during the time period July-October 2017, was in correlation with wet seasonal changes. Several factors and conditions such waste composition, air temperature, topography, pressure, pH and microbial interactions are considered important for methane generation and emission from landfills (EPA, 2001; Zawieja, et al., 2011). Air temperature and rainfall are strongly correlated with methane generation in the landfill (Yang, et al., 2015). Temperature is the dominant factor influencing landfill gas production. Drier and warmer conditions would lead to an increase in the landfill gas production (Bouzonville et al, 2013). The seasonal variability of methane emissions into the atmosphere is also characteristic of landfills without an active ventilation system (Bogner, et al., 2011). In seasonally cool and/or dry climates, a reduced rate of CH_4 oxidation can be expected. This is consistent with lower winter rates of methanotrophic oxidation (Ronald et al., 2000). Methane is not only dangerous as a GHG, but is also highly combustible. Methane is explosive between its LEL of 5% (50,000 ppm) and its upper explosive limit of 15% (150,000 ppm) by volume (Yaws, 2001). In the case of combustible gas concentration at 10 to 50% LEL from a port entry (~5,000 to 28,000 ppm) are recommended control measures

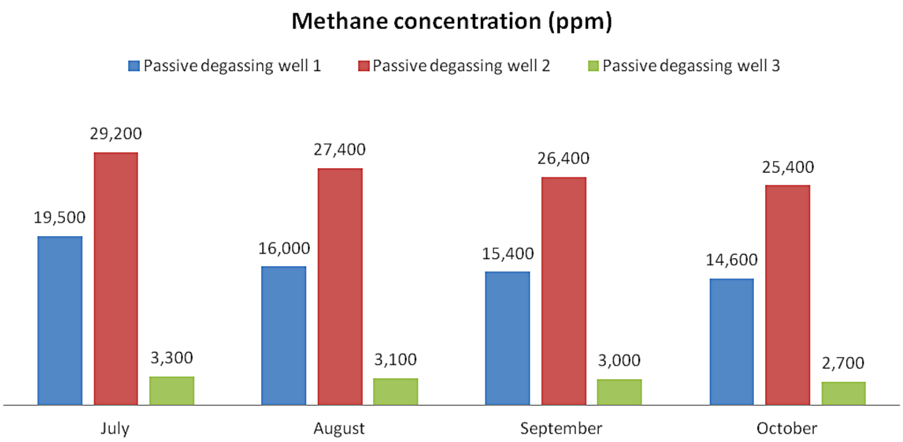

Figure 7. Average methane concentration, July-October 2017 (ppm)

Table 4. Abbreviations

%	Percent
^0C	Celsius
CH_4	Methane
CO_2	Carbon dioxide
EU	Europe Union
GHG	Greenhouse gas
Ha	Hectare
LEL	Lower explosive limit
LFG	Landfill gas
MSW	Municipal solid waste
PE	Petroleum
Ppm	Parts per million
S	Seconds
T	Temperature
UEL	Upper explosive limit

and installing a ventilation system (MPCA, 2011). In the boundaries of the landfill, methane concentrations are typically well above the UEL, reaching as high as 50% by volume. However, as the methane travels away and diffuses into the surrounding atmosphere, it does begin to dilute to non-explosive concentrations. While these occurrences are rare, the incidents of explosions suspected as having been caused by the methane originating from landfills have been reported (ATSDR, 2001).

CONCLUSIONS

The measurement of the CH_4 from sanitary landfill for the Gjilan region was performed in situ. The performed in-situ measurements of the released amount of methane showed that the observed the concentration of methane in the municipal landfill is within the lower explosive limits. Seasonal variations of the concentration of the methane in the sanitary landfill observed during time period July-October 2017 were in correlation with wet seasonal changes. Control measures and installing a ventilation system in the landfill are recommended.

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