Methodical instruction
for determination of surface emissions on landfills using a special sampling device

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I. Introduction

The main purpose of this methodical instruction is to describe the utilization of a new method used to measure the emissions of methane, based on the principle of determination of conversion factor between surface concentrations and material gas flow.

Landfills are significant sources of air pollution. As a consequence of decomposing processes of stored waste, landfill gas composing mainly of methane and carbon dioxide is formed. Since methane is a significant greenhouse gas, it is necessary to reduce its emissions as much as possible. It is important to check effectiveness of technical measures that prevent the escape of methane into the atmosphere using the method of field measurement. However, current legislation does not set down a single methodology of this measurement. Presently the static flux-box method is often used to determine the emissions of methane on the surface of landfills, however this method is inaccurate and time-consuming. Because of this, a fast and relatively accurate direct measurement method that can fill the gap in emission monitoring on disposal sites, and contribute to the improvement landfill gas management was designed.

II. Description of the sampling device

Description of the innovative sampling device

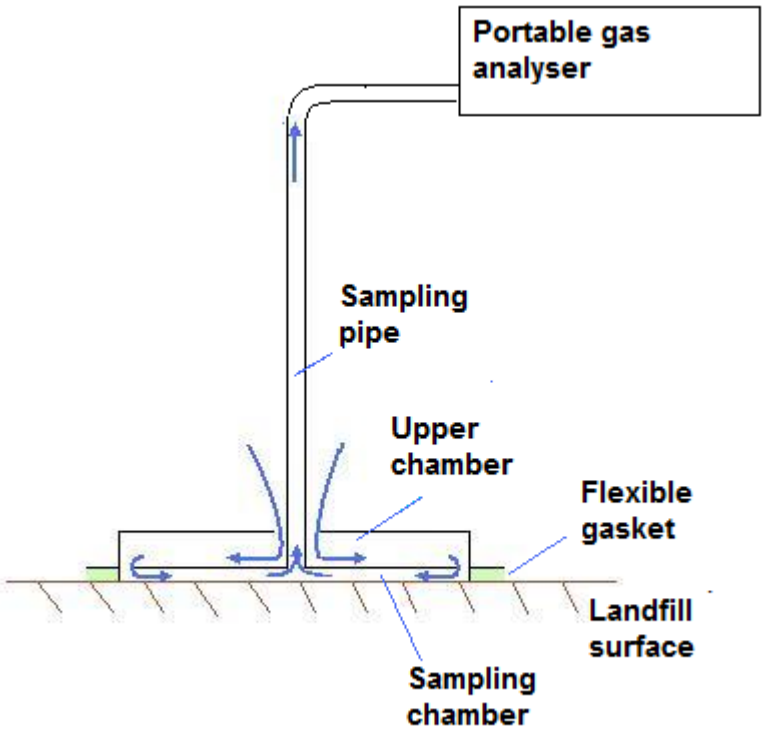
A flat circular device with a flat cylindrical sampling chamber is used to measure the flow rate of methane. The edge of the device is bordered with a flexible foam gasket in order to provide tightness. A sampling tube is connected to the analyzer and leads from the sampling chamber of the device that covers the measured surface of the landfill. The upper chamber of the sampling device that is placed above the sampling chamber is linked up to the perimeter of the sampling chamber via apertures and leads to circular opening in the central upper part that is used to draw fresh air into the sampling device (see Figure 1). The sampling device is covered by Czech patent no. 304199.

Requirements for parameters of the analyzer

The analyzer that is attached to the sampling device has to be mobile and meet the following parameters:

- Measurement range 50 – 500000 ppm CH_4 (selective measuring of CH_4)
- Adjustment of the drawing of sample air to 4 liters per minute
- Adjustment of evaluating of methane measurement to integrated measurement, adjustment of the preintegration time to 1 second and integration time (time of the analysis of drawn air) to 10 seconds
- Intervals between individual analysis of methane are 0.1 second

Figure 1: Scheme of the sampling device representing air flow in it



III. <u>Principle of determination of surface emissions of methane on landfills using the sampling device</u>

The measuring method is based on the measurement of the methane concentration on the surface of a disposal site that results from a diffusion inflow of methane into the special sampling device in set measuring interval. The principle of the sampling device is based on a flat cylinder sampling chamber that is connected to the upper chamber via apertures and by means this upper chamber that is freely connected to the atmosphere via an opening

in the center of the upper chamber. This arrangement provides minimization of pressure loss during sampling from the sampling chamber and hence minimization of the suction of soil air from under the surface of the disposal site, by drawing of sample air from the sampling chamber into the analyzer.

There is a flexible foam gasket attached to a firm annulus that provides the tightness of field unevenness around the sampling chamber along the outside perimeter of the sampling chamber.

The sample of air containing methane is drawn from the sampling chamber into the mobile analyzer of required parameters, such as ECOPROBE 5, in which the measuring of collected methane is made using an infrared analyzer. The measurement of methane concentration is converted to an average concentration of methane from the sample at the end of each sampling interval. The measured value is interpreted using the regression equation that is obtained from the calibration of the sampling system on the methane emission simulator that has a known methane flow rate per an area unit at a time (litres/m^2/hour).

IV. Description of the measurement on landfill

The method of the measurement in the field is as follows:

1. Tightly attach the flat area of the sampling device to the surface of the disposal site that has a soil cover of the surface available, or on a heterogeneous mixture of waste (not where it is mainly covered by one piece of waste, such as a board or plastic foil) and press so that the metal edge of the sampling chamber at the bottom of the sampling device is attached to the landfill surface. The ring of the flexible gasket ensures filling up of possible unevenness of the field around the sampling chamber at the same time.
2. After 30 seconds of pressing the sampling device to the surface of the disposal site, set off the analyzer whose parameter adjustment is set to 1 second preintegration time and 10 second integration time. The requirements for the sampling are drawing of 4 liters per minute, measurement interval of methane in the analyzer during integration time at 0.1 measurement per second.
3. The process of sampling and sample analysis (it takes 11 seconds including 1 second flushing of the intake pipe during the preintegration time)
4. Ventilate the sampling chamber in free air (approximately 15 seconds, for example by swinging during walking to the next sampling place); flush the sampling pipe before next measurement by fresh air in case sampling concentration reached maximum value over 1000 ppm of methane.

Time of measuring at one place takes 41 seconds, subsequent ventilation takes additional 15 seconds. The overall time of one measuring takes approximately 1 minute. This interval may be longer in practice, depending on distance between

individual sampling poins. Sampling points should be as far as possible regularly distributed on the landfill surface, so that the whole site surface was represented.

V. Calculations

Calculation of methane emission from the surface of the disposal site

Regression equation for determination of methane emission in litres per m^2 per hour for one measurement is stated as follows:

$$y = 0.0031x \qquad (1)$$

where:

x is an average concentration of methane in the air taken from the sample drawn using the sampling device during 10 second integration time (ppm methane)

y is the emission flow of methane at the sampling place (litrers/m^2/hour)

Frequency of measuring: minimum 1x year in a typical season at weather condidions without extreme changes of barometrical pressure. It is recommendable to repeat the measurement several consecutive days and average results.

Accuracy of measuring

The regression dependence with the correlation coefficient $R^2 = 0.9577$ is determined by testing the sampling device on the simulator of methane emission from the surface of a disposal site. Deviations in measuring vary according to methane flow rate.

According UKEPA (1986) it is necessary to perform the following number of point measurements using flux-box (this method provides similar results to the sampling device) in order to determine methane emissions from a homogeneous region of a disposal site:

$$n = 6+0.15 \sqrt{Z} \qquad (2)$$

where:

Z is the area of homogeneous region of the disposal site in m^2.

n is the number of individual measurements.

However, homogeneity of the surface of the disposal site is very hard to reach in practice. The surface of a disposal site where mostly only one kind of waste is stored for at least one year at rest (without waste placing) and covered with at least 0.3 m of soil cover can be considered as a homogeneous surface. On the basis of the results obtained from practical measuring, the equation above can be rearranged in order to suit nonhomogeneous surfaces as follows:

$$n = 6+ \sqrt{Z} \qquad (3)$$

where:

Z is the area of nonhomogeneous region of the disposal site in m^2.

n is the number of individual measurements.

The overall methane emission from the disposal site can be calculated using the following equation:

$$F = P * (\sum x_i) / n \qquad (4)$$

where:

F is the overal methane emission from the surface of the disposal site in litres per m^2

P is the area of the measured tract of the disposal site in m^2

n is the number of individual measurements

$\sum x_i$ is the sum of all methane emission values taken from individual measurements, the value i ranges from 1 to n

Statistical assessment of results

The measured values measured on landfill gas emissions simulator have normal distribution, however in the case of a real landfill surface, the real flow values fluctuate several orders of magnitude. Emission point with high emission flow are quite rare on a landfill, so individual high emission values hit by the sampling grid have a significant influence on the overall result. It was found empirically that log-normal distribution is a plausible model for description of this situation on most landfills. Use of this distribution model allows to state a confidence interval for methane emissions measurement. The confidence interval of this statistical distribution model is rather assymetrical, with lower limit close to the mean value and the upper limit quite distant from the mean value. This property of the confidence interval reflects the high influence of the rare high emission values on the whole data set.

VI. Abbreviations and terms used

Preintegration time – period of time where air is taken into the analyzer just for flushing of the intake tube

Integration time – period of time during which air taken into the analyzer and measurements of the amount of methane are underway

Integrated measurement – measurement during which average values of the whole drawn sample from one sampling are evaluated

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