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Risk assessment

INVESTIGATION OF LANDFILL GASES ACCUMULATED IN UNDERGROUND (SOIL/SUBSOIL) NEAREST MUNICIPAL WASTE DISPOSALS

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Abstract. The purpose of the present paper is to show investigation results performed to identify the landfill gases accumulated in underground (soil/subsoil) in 2 locations (case studies) situated nearest municipal waste disposals. The investigation is focused *in situ* measurements with a portable gas analyser for landfill gases (methane, oxygen, carbon monoxide, carbon dioxide and hydrogen sulphide). For investigations was applied an intrusive method, respectively a manual drilling with a hand auger equipment and the boreholes were equipped with polypropylene (PP) airtight pipes provided with the gas tap. Drilling within 2-m depth permitted to describe a local lithology and to indentify the peculiarity aspects. To obtain more information about possibility of landfill gases to migrate and accumulate 'off site' the main sources, the permeability tests was performed in laboratory. The characterisation of the landfill gases accumulated in boreholes was performed in multiple campaigns in order to obtain results in different weather conditions (temperature, pressure, precipitations) to establish a temporal evolution of these emissions. The investigations results will be applied in the methodology of risk assessment in areas located in the vicinity of sources of landfill gases in the framework of future developments.

Keywords: landfill gases, hazardous gases, methane, borehole, risk assessment.

AIMS AND BACKGROUND

Climate change is caused by an increasing level of greenhouse gases in the atmosphere. Methane gas is a greenhouse gas that is 23 times more harmful than the same volume of carbon dioxide[1].

One of the main sources for methane is landfills and most of the methane gas produced from the landfills leak into the atmosphere and contribute to global warming. There are several hundred of old landfills in Romania and these landfills are not used to utilise methane gas and use it as renewable energy.

Old landfills are often located close to cities on valuable land, these landfills are often converted to parks and walking areas after closure, but due to the production of methane in old landfills there is not much construction on these sites due to the instability of the ground for buildings. Another concern is that there is no

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clear usable regulation and exposure limits for methane gas from old landfills in order to know at which production rate is dangerous for humans[2].

Monitoring of subsurface gas probes should include the measurement of the concentrations of methane, oxygen, and carbon dioxide as well as the measurement of the gas pressure within the probe and the barometric pressure at the time of the monitoring. For landfills, oil fields, or other sites where the presence of hydrogen sulphide is suspected, analysis of hydrogen sulphide should also be included[3].

EXPERIMENTAL

Locations. To apply investigation methodology for gas emissions in underground in areas with potential to generate these emissions were chosen 2 locations of waste disposal with specific peculiarities. The first location is situated in west of Bucharest, an old waste disposal with activity stopped 20 years ago; the second location is in Suceava, respectively a waste disposal where the activity is stopped in first decade of the year 2009.

The common features of these 2 deposits consist in absence of improvements to protection of environmental compounds: geological barrier for impermeabilisation, percolation waters are not collected and treated and gas emissions are not improved.

The main physical properties of wastes are: density and humidity and distribution in conformity with particle size[4].

Densities of solid waste are in correlation with composition, humidity and compacting rate. For both waste disposals these information about solid wastes is not available. From that must stipulate that the investigation was focused in the vicinity of potential sources, respectively nearest waste disposals in order to identify the possibility of gas accumulation in underground. Possibility of gas accumulation is related to local geological conditions in these areas.

Investigation methods. The methodology CIRIA guide C665 (Ref. 5) is a powerful tool for case studies, furthermore in the vicinity of the waste disposal in the western part of Bucharest is possible to extend residential areas in near future.

Applicable investigation techniques are grouped in 2 main categories: non-invasive and invasive. In the 1st category are mentioned: infrared photography, aerial thermography, satellite imagery/aerial photography. The advantages of these techniques consist in possibility to investigate large areas in short periods of time, but the investigations must be completed with other investigations based on invasive techniques. In the 2nd category are mentioned: borehole and trial pits realised with manual or mechanical equipment. These investigations permit to identify the local lithology and measure the gas concentrations with proper gas analyser equipment.

The characterisation of landfill gases accumulated in boreholes was performed with a GA2000Plus analyser, in multiple campaigns in order to obtain results in different weather conditions (temperature, pressure, precipitations) to establish a temporal evolution of these emissions. Gas analyser permitted to measure 5 gases and simultaneous display of all gasses: CH_4, CO_2, O_2, CO (with hydrogen compensation) and H_2S.

RESULTS AND DISCUSSION

The analysis of lithology and permeability tests put in bold line the following aspects:

– predominant lithology was represented by sedimentary layers;

– a low permeability specific of mixture of clay, sand and silt (specific for sedimentary rocks);

– presented differences in permeability from one borehole to another, the greatest value of hydraulic conductivity was identified in location situated in the west of Bucharest. In this location water penetrates rapidly underlying layers.

The gas measurements performed in period August 2009–July 2010 have highlighted the presence of methane in one borehole (F2) situated in the vicinity of waste disposal located in the west of Bucharest, where concentrations in all period of investigations stayed in the range 41.5–60.5 % (v/v) methane (Fig. 1). The evolution of oxygen and CO_2 regime is shown in Figs 2 and 3.

The F2 borehole is located at 80 m from the mass of deposit, but the local conditions not preclude the other wastes to be buried in this area. Areas are made more recent uncontrolled waste and it is not clear if the methane source is local or comes from migration of landfill vicinity. The weather conditions at the moment of measurements were characterised by: clear and partly cloudy days with thermal regime between 6 and 32°C, and atmospheric pressure in the range 992–1012 mbar.

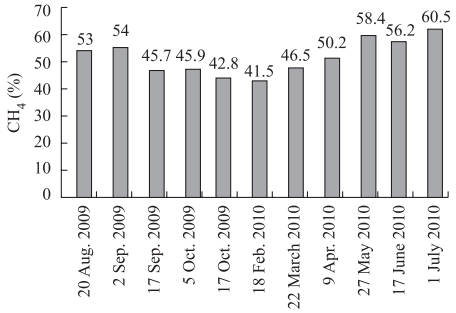

Fig. 1. Evolution of methane concentration in borehole F2

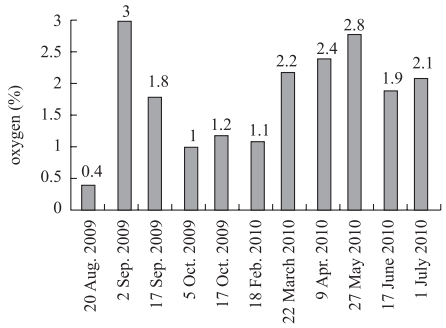

Fig. 2. Evolution of oxygen concentration in borehole F2

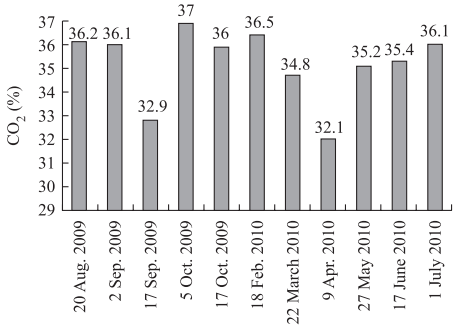

Fig. 3. Evolution of CO_2 concentration in borehole F2

A number of favourable factors for methane emissions were identified in this area:

– presence of a nearby marshy area;

– groundwater level is close to the surface;

– higher permeability for water in this area;

– identification of the buried wastes at the moment of the drilling execution represent a potential source of the methane emissions.

For Suceava deposit in the period August 2009–June 2010 was identified methane concentrations in the range 0.1–0.4% in borehole SV2 (Fig. 4) and CO_2 concentrations between 3.6 and 15.4% (Fig. 5); the weather conditions at the moment of measurements were characterised by: clear and partly cloudy days with thermal regime between 2 and 24°C, and atmospheric pressure in the range 963–987 mbar. Investigation of methane emissions inside landfill revealed in this field 0–58% methane concentrations, maximum concentrations found in the eastern landfill where waste has been deposited recently. Lack of coating layer makes the emission of landfill gas to be discharged directly into the atmosphere, which explains why it has not registered migration and accumulation in underground.

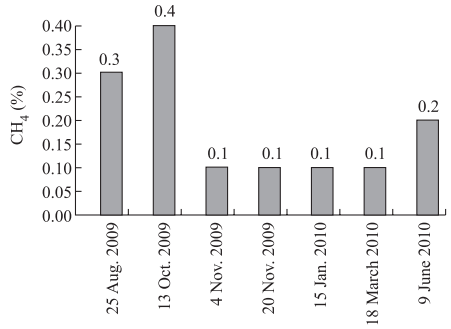

Fig. 4. Evolution of methane concentrations in borehole SV2 Suceava

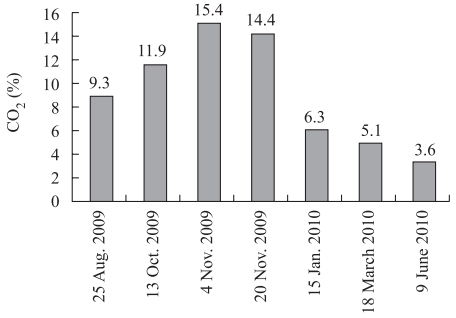

Fig. 5. Evolution of CO_2 concentrations in borehole SV2 Suceava

Specific features of deposit Suceava are as follows:

– the landfill where work storage has been recently completed;

– there are areas where uncontrolled waste are deposited;

– wastes not covered by a layer of soil limit the possibility of underground methane migration.

CONCLUSIONS

In the context of future development areas located in the vicinity of municipal waste disposals it is very important to apply investigation methods in order to assess risks posed by the accumulation of hazardous gases.

The increased methane concentrations recorded in the borehole near the landfill situated in the western part of Bucharest require widening investigations on the generation, migration and accumulation of hazardous gases in this area. The area was heavily anthropogenically altered without existing the information on how waste was disposed in the area, if there was performed a compactation of the wastes and, especially, about the deposit stability behaviour after its closure.

The anthropogenic factors are responsible of the increase of the permeability in rock pores for gas and create the possibility of the methane to migrate and to

accumulate. The local lithology consist of the sedimentary layers, is favourable to the gas migration in soil and underground. The low concentrations of methane in the landfill near Suceava can not exclude the possibility of landfill gas migration. For this deposit were identified the following features: short period after the closure of the activity and the partial covering of the deposit, which determines mainly the gaseous emissions to discharge directly into the atmosphere.

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