Flow modelling for The Construction of The Soil gas ventig systems

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Introduction

In 1999 the hydrogeological and geotechnical investigations for construction of the large shopping centre were performed showing not documented landfill site. It was recognized that the area intended for construction of the shopping centre served in the past as an illegal not documented refuse dump. The investigation area was located in the centre of large town of Kraków, Poland. This part of city has a high density of blocks of buildings and service lines. During drilling and sampling activities small explosions were observed in same boreholes. This caused the stopping of the works and forced the investor to perform additional investigations for soil gas quality.

Soil gas sampling and interpretation of the measured data

The authors were involved on all stages of these investigations, from soil gas sampling through gas flow modelling to designing and construction of the venting system. Not documented landfill site was located 5 m below ground level (Fig. 1). The volume of the wastes was estimated to be 216.000 m3. The total amount of the refuse that were disposed in the landfill was 200.000-220.000 tons. The soil gas sampling using the Dräger gas probe was made in more than 200 points located in the area of 52.500 m2. The samples were taken at depths of 1, 2 and 3 m, using the driven soil gas probe. The concentrations of the explosive gases were measured. The landfil gas contained CH4 and H2S. The sampling data were used to generate maps of CH4 and H2S concentrations by use of the 3D geostatistical simulation [1,2,4]. As result, the contaminated area was estimated to be as high as 43.400 m2. The selected maps of concentrations are presented in Figs 2,3. It may be seen that the explosive and toxic gases were detected in the soil gas with maximal concentrations of: H2S up to 57 ppm, and CH4 up to 65%. The additional transient tests performed in observation wells resulted pure methane flow in the range of 0,5 m3/hr to 1m3/hr.

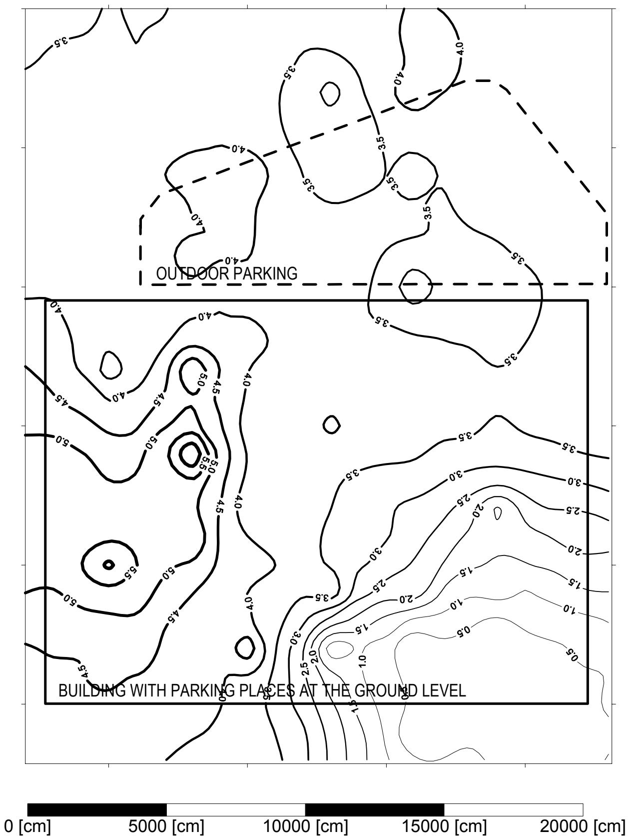

Fig. 1. Thickness of waste layer (field investigations)

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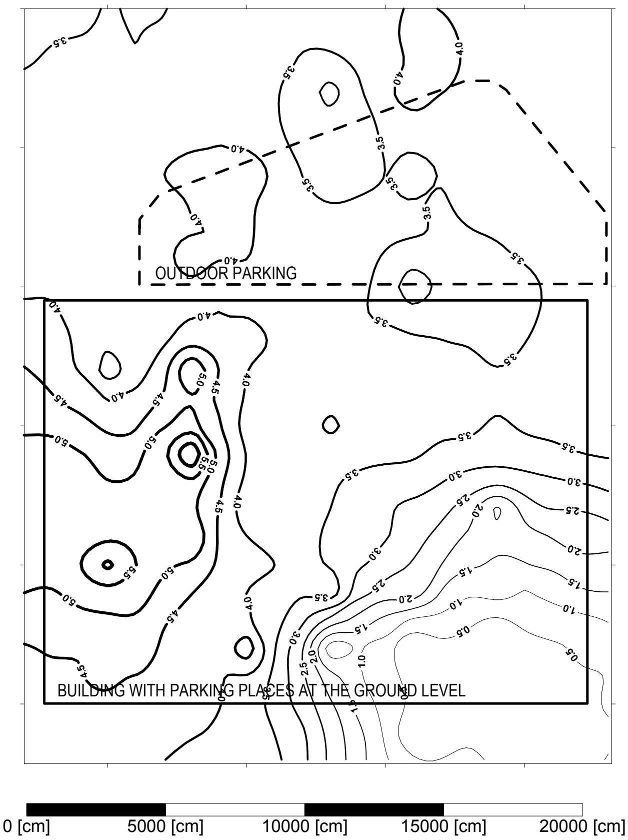

Fig. 2. H2S concentration in soil gas at 2 m depth, ppm (field investigations)

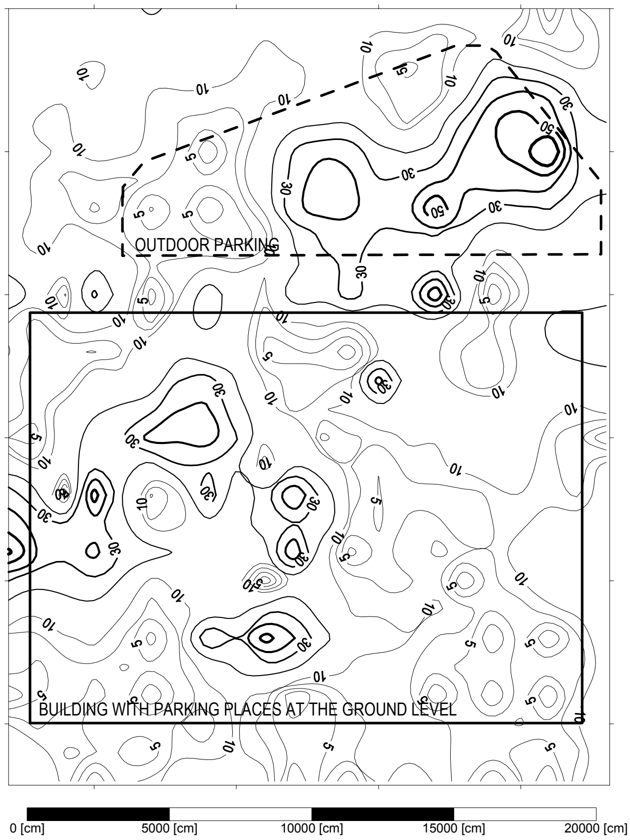

Fig 3. Methane concentration in soil gas at 2 m depth, % (field investigations)

Modelling of the landfill gas emissions

Air emissions from landfills come from landfill gas, generated by the decomposition of refuse in the landfill. Landfill gas is a product of biodegradation of refuse in landfills and consists of primarily methane and carbon dioxide, with trace amounts of Nonmethane Organic Compounds (NMOC) and air pollutants. Gas emissions from landfill were estimated using the Landfill Gas Emissions Model, [3], (Land GEM) – public domain software accessible from EPA web site (www.epa.gov). The model assumes that the generation of methane from a landfill is a function of two values: k - the methane generation rate constant, and L - methane generation potential. Landfill Gas Emissions Model estimates emissions of methane, carbon dioxide, nonmethane organic compounds, and selected air pollutants.

Assuming the scenario of the landfill operation presented in Table 1. The forecasts of the emissions were computed. Results of simulation are presented in Fig. 4

Tab. 1. Data set assumed for emissions prognose.

Landfill Scenario Model Parameter Data:	
Landfill Type:	**Co disposal - hazardous waste as well as other kinds of waste in a landfill**
Year Opened:	1960
Current Year:	2000
Landfill Capacity:	216.000 tons
Refuse in Place in 1980:	216.000 tons
Annual Refuse Acceptance Rate:	54 tons/yr from 1960 to 1964
Closure Year:	2010 – In Fig 4
Methane Generation Rate (k):	Default – k=0.05 l/year
Methane Generation Potential (L):	Default - L=170 m3/ton of refuse
Percentage Composition of CO and CH:	50%/50%
Concentration of NMOC:	Default - 4000 ppmv of NMOC
Selected Air Pollutant:	NMOC (MW = 62.13; concentration = 0.86)

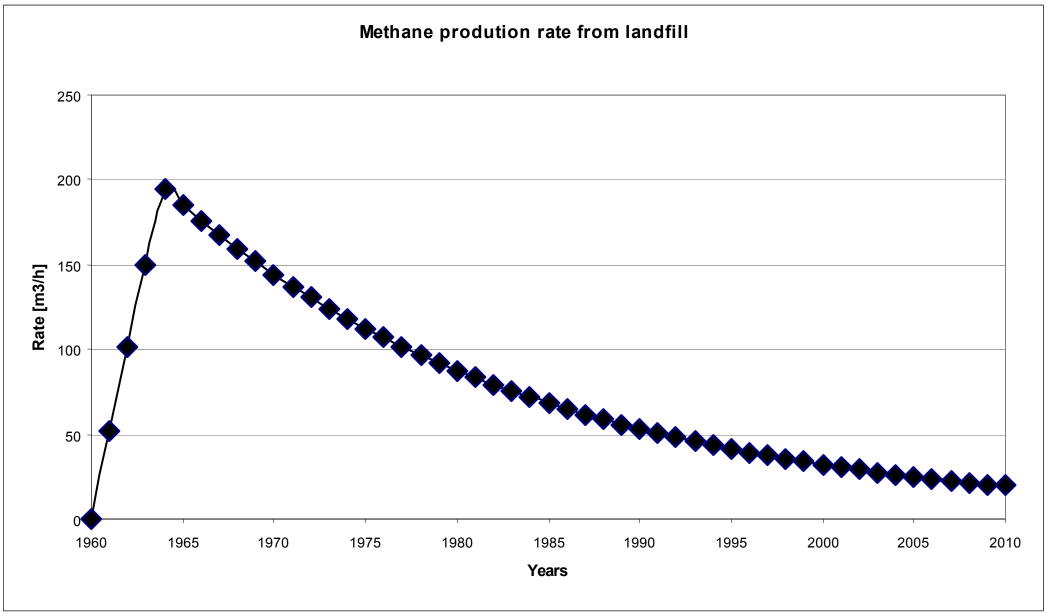

Fig. 4. Projected methane emissions

Modelling of the soil venting

In order to remove the dangerous gases, the soil air venting system was proposed. For the public safety reasons the decision to build the soil venting system was taken. Because the landfill site was still active (Fig.4), the main assumption for the venting system was that it should work continuously, without maintenance, for a long time. This system was optimized and designed on the base of flow modelling. The computer modelling of the soil venting was performed in order to identify the flow conditions at a given site and to evaluate possible venting performance. The modelling was performed using different software and the results were compared [6]. In this paper results of the numerical simulation using compositional reservoir simulator ECLIPSE 300, [4], are presented. ECLIPSE 300 is a multi phase, three dimensional, general purpose compositional simulator with cubic equation of state, pressure dependent K-value and black oil fluid treatments, commonly used in the petroleum engineering applications. ECLIPSE 300 can be run in fully implicit, IMPES and adaptive implicit (AIM) modes.

The drainage radii of the wells were calculated as the distance where the velocity drops to 0.5% of the value at the borehole. It was assumed that initially the pressure drop in the wells was forced by vacuum pump to the value of □P=2*104 Pa. The optimal distance between horizontal wells was estimated to be 40 m. The data used for calculations are presented in Table 2

Tab. 2. Input data sheet

Gz = 1.79·105 m3	Volume of the refuse heap (calculated)
Gdg = 2.29·104 m3	Volume saturated with methane
Sz = 4.34·104 m2	Area extent of the methane saturated zone
□ = 25 %	Porosity
K = 8·10-12 m2	Permeability
T = 18 oC	Temperature
Pa = 1.01325·105 Pa	Atmospheric pressure
□ = 1.75·10-4 Pa s	Gas viscosity
rw = 0.05 m	Well radius
zw = 4 m	Depth of the well
Ls = 1 m	Perforations length
H = 5 m	Depth of the ground water table
Mm = 4.1·103 kg	Mass of the methane for venting

In Fig.5 the simulation of the methane content (molar fraction) in the soil gas after 4 days is presented.

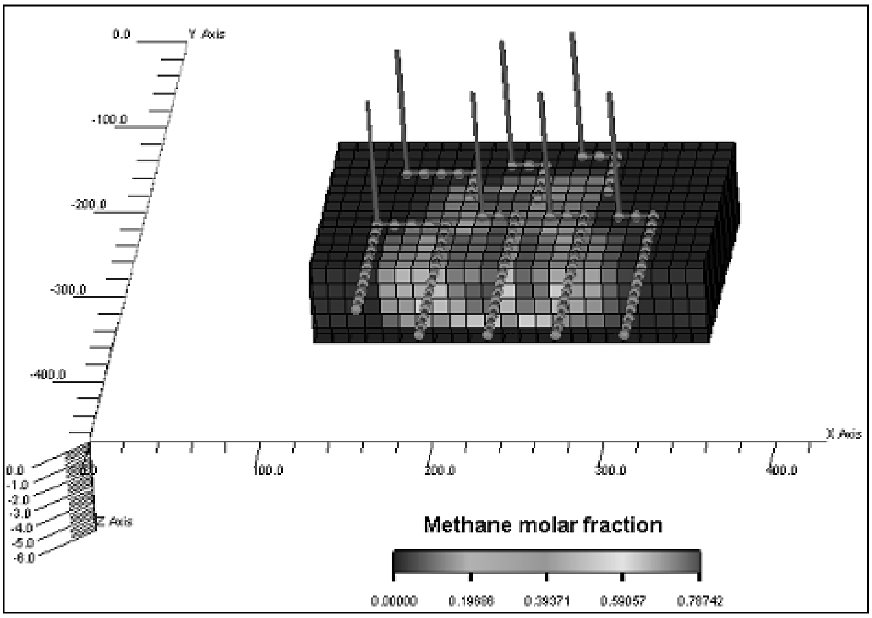

Fig.5. Simulation of the methane content (molar fraction) in the soil gas after 4 days of ventilation

Fig. 6 shows the molar fraction of methane in gas produced by the venting system vs. time. One may observe that the time of effective venting is about 50 days.

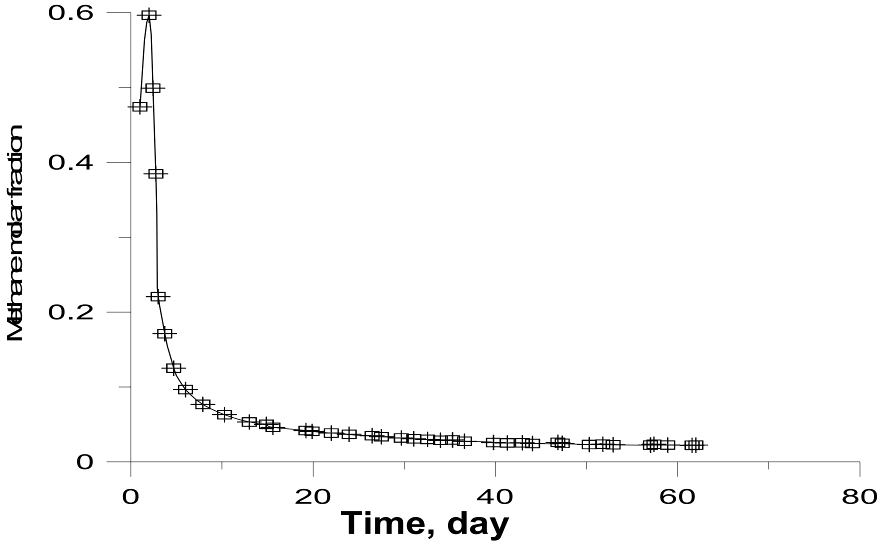

Fig. 6. Methane content in gas produced from the venting system vs. time

On the basis of the simulations presented above, the venting system included the horizontal drainage was build. The system consisted of 8 horizontal wells with length between 80-140 m. The total length of the drainage system was 700 m. Some construction details are presented in Fig.7 and Fig. 8.

Coclusions

1. Geostatistical simulations using the data from soil gas sampling made it possible to generate high quality maps for characterization of the landfill site. These maps served as the basis for simulation of the soil venting system.
2. The air emissions and landfill chemical activity were simulated successfully using Landfill Gas Emissions Model
3. Construction of the soil venting system removed the dangerous gases from ground and made it possible to use the old landfill site for building purposes.

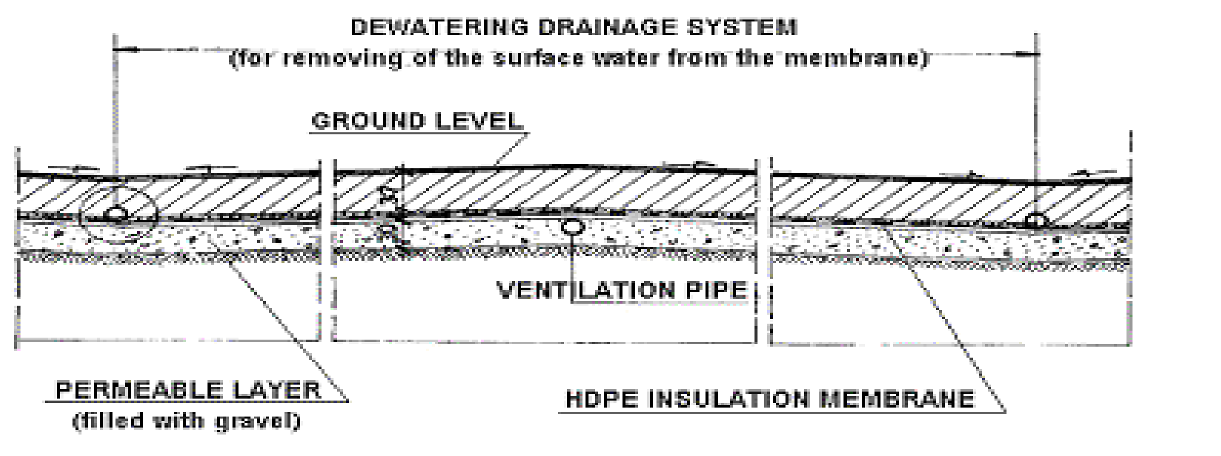

Fig. 7. Cross-section of the soil gas venting system

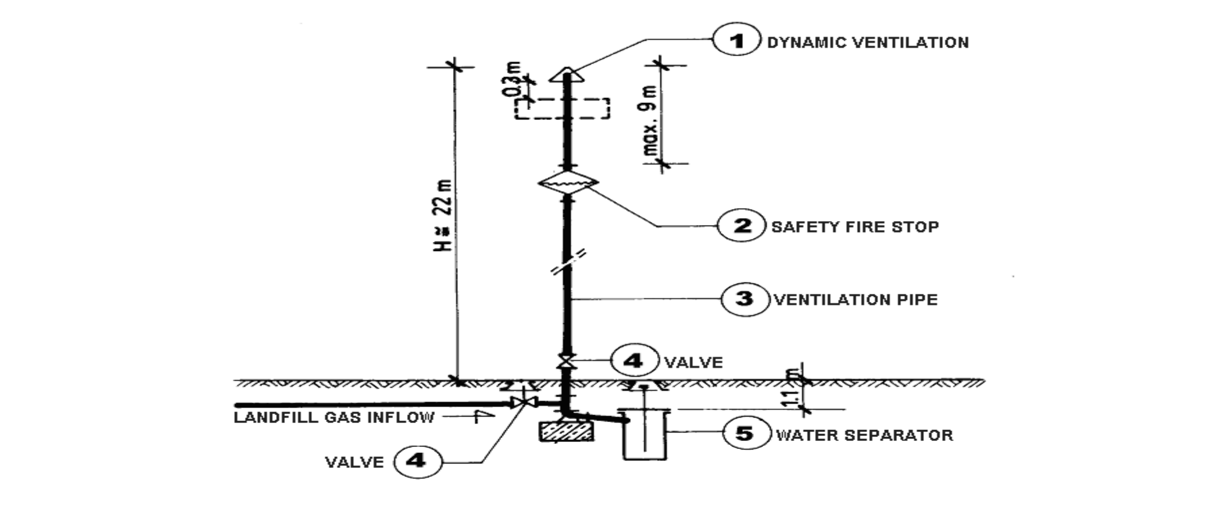

Fig. 8. Outlet from the venting system

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