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Methane emission in landfill gas at two closed waste disposal sites in Istanbul, Turkey

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In this study, methane emission was measured using micro gas chromatographic methods in Hasdal and Yakacik sanitary landfill areas in Istanbul city. Methane levels were found as 21.76-36.90% in Hasdal and 13.52-51.78% in Yakacik. Methane effects on environmental and public health were discussed.

Keywords: Energy, Methane, Solid waste

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Introduction

Solid wastes deposited in sanitary landfill areas decompose through several chemical, physical, and biological processes, leaving a number of byproducts[1]. Though some chemical and physical processes contribute to the decomposition of the waste, the most important process the biological one[2]. Landfill gas production is a biological process, in which carbon dioxide (CO_2), methane (CH_4), and other trace gases are formed with the action of microorganisms on organic wastes[3]. It is estimated that complete biological decomposition and gas production can take 30-100 years, but these processes frequently occur in less time. Under normal circumstances, the landfill gas produced reaches its maximum level in two years, and begins to decrease afterwards. Nutrient content, temperature, moisture, pH, particle size, density of waste, and the composition of waste buried are important parameters affecting gas production in solid waste landfill areas[1,4,5].

The gases emitted from landfill are CH_4, NH_3, CO_2, CO, H_2S, N_2, and O_2. Methane (45-60%) and carbon dioxide (40-60%) are principal gases occurring from anaerobic degradation of domestic solid wastes[6-11]. Landfill gases cause several environmental[12] (fires and explosions, global warming[13], hazardous effects to plants, underground water pollution, and unpleasant odors) and public health problems. Methane has an effect of 20-25 times more than that of CO_2 to global warming in molecular basis and its residence in atmosphere is longer than CO_2[14-16]. Landfills comprise one of the principal sources of anthropogenic CH_4 emission and are estimated to account for 3-19 % of anthropogenic CH_4 emission globally[17].

In this paper, methane gas measurements were performed in Kemerburgaz-Hasdal and Yakacik rehabilitated landfill areas, and gas production and usage potentials of the facilities were investigated.

Materials and Methods

Study Sites

Istanbul city is located at 41°N and 29°E, and is a metropolis with 5700 km^2 area. Two solid waste deposition places, Hasdal and Yakacik were selected as working areas (Fig. 1, Table 1). Kemerburgaz-Hasdal solid waste deposition area has a space of 577 000 m^2 and waste deposition in this area was started in 1980. Deposition was discontinued in 1998, and rehabilitation was started by covering this area. Waste volume is estimated to be 8.2 million m^3, and drawn from domestic, commercial, and industrial sources.

In 1999, a system was built to generate electrical energy from the area, and 180 gas collecting wells were established[18]. In the central facility, 4 generators capable of generating 1 MW power are in operation. Gas

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Fig. 1— Positions of Kemerburgaz –Hasdal and Yakacik solid waste deposition areas

Table 1 — Summary of two dumping sites

Site	Area, m^2	Waste types	Gas end use
Hasdal	577 000	Domestic waste and trade waste (8.2 million m^3)	Landfill gas extracted to fuel four engines for electricity generation
Yakacik	80 000	Domestic waste and trade waste (600000 m^3)	Gas extraction system and flare

combustion and energy production in the facility is continuous. Since 1979, domestic and industrial wastes from Kartal and Pendik counties were deposited into Yakacik landfill area[19] storing 600 000 m^3 waste in 80 000 m^2. In 1995, this area was rehabilitated by covering with soil and landfill gas was harvested through 11 vents. Only one gas combustion unit has been working since 1997. Gas combustion is intermittently continued, depending on flow rate.

Instrumental Analysis

Methane gas analyses were performed on Varian CP-4900 Portable Micro Gas Chromatograph, with TCD detector and Mol Sieve 5Å column. Column was 10 m long and carrier gas was argon. Column and injector temperature was 50°C, injection time was 40 milliseconds, back flush time was 90 second, and pressure was 39 psi. Pressure and temperature programming was not used on the column, and constant pressure and temperature was applied. The system was operated by a connected notebook with Microsoft Windows(R) operating system and Varian Star(R) software. Standard methane gas was used for Micro GC calibrations. Standard calibration gas was injected externally and the peaks were checked. Gas samples were collected and injected with a gas-tight syringe.

Results and Discussion

Methane gas estimations were done in triplicate in different sampling times, from both landfill zones. Chromatograms from Hasdal and Yakacik zones are presented in Figs 2 and 3. Methane concentrations were found to be: Hasdal zone, 21.74-39.90; and Yakacik zone, 13.52-51.78% (Table 2). Methane concentrations

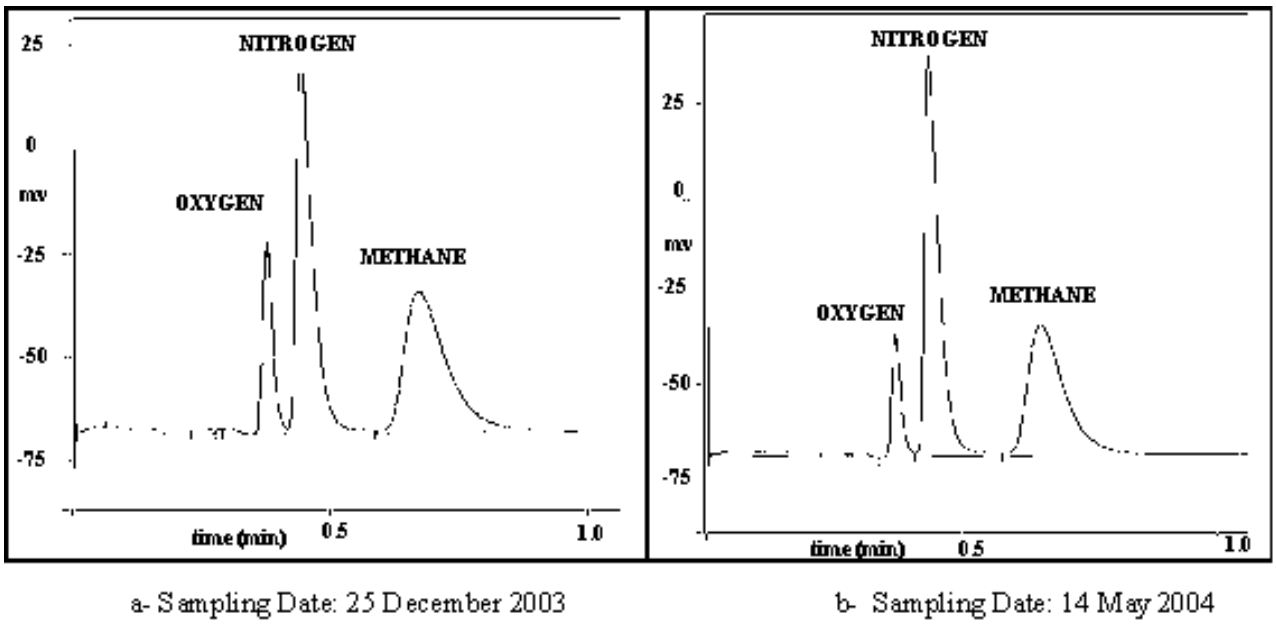

Fig. 2 — Annotated chromatogram of methane in landfill gas samples at Hasdal

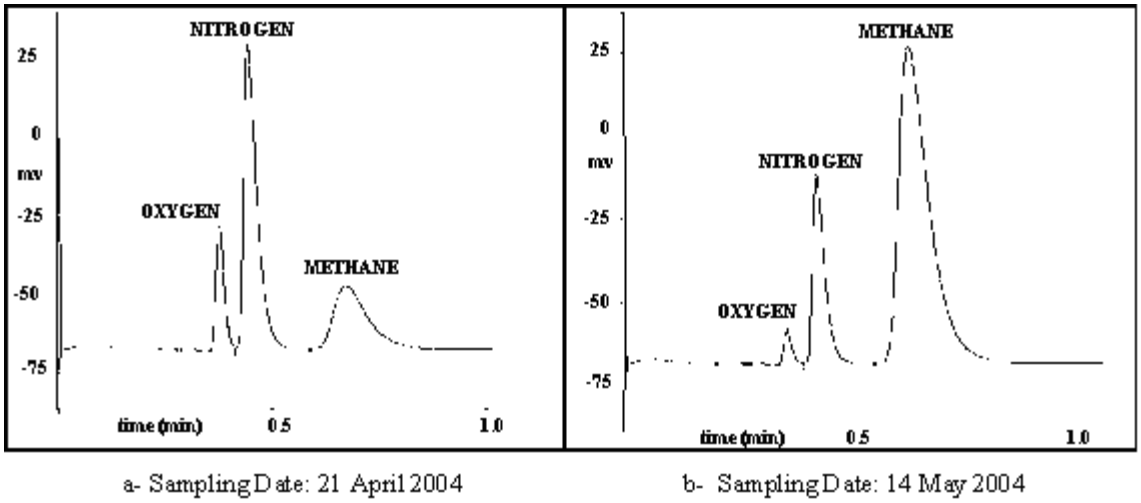

Fig. 3 — Annotated chromatogram of methane in landfill gas samples at Yakacik

Table 2 — Methane concentrations calculated for Hasdal and Yakacik Landfills

Landfill site	Sampling date	CH_4 vol %
Hasdal	25 December 2003	21.74
	14 May 2004	20.73
	24 June 2004	36.90
Yakacik	21 April 2003	13.52
	14 May 2004	51.78
	24 June 2004	21.29

were lower than the standard values since both landfill zones are not sanitary landfill type disposal areas.

Until 1990, uncontrolled disposal had continued into these areas. Rehabilitations were done in Yakacik in 1995 and Hasdal in 1999 by building gas collection and combustion units. The most important factor reducing the amount of gas is that the gas collecting units were not built when the wastes were disposed and the wastes were exposed to air for quite long. Methane gas and electrical energy generated in Hasdal landfill gas processing and electric generation facility are presented for 2004 and (Fig. 4).

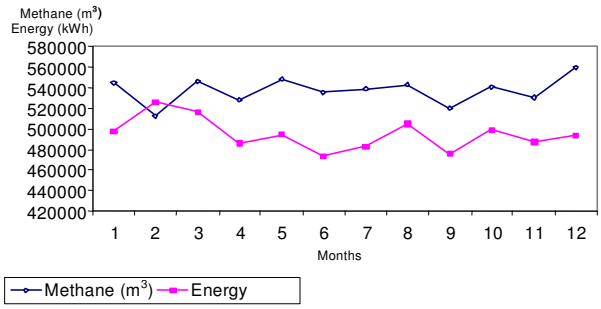

Fig. 4— Monthly changes of methane and energy productions in Hasdal Facility during 2004

Conclusions

The average methane concentrations in Hasdal and Yakacik facilities were 24.45% and 28.86%, respectively. In Hasdal facility, methane combustion and energy generation unit processed 6.45 million m^3 methane gas and generated 5.94 kWh electrical energy, during 2004. Although average methane concentrations were not too high in both sites, these values were higher than flammable limit concentration. This study clearly shows that combustion of landfill originated methane is both necessary and beneficial with electric power production in closed and rehabilitated old unsanitary solid waste disposal sites.

Both landfill zones selected are rehabilitated old waste disposal sites. The methane concentrations and gas amounts, along with energy generation values, will provide an example for still operating zones about rehabilitation and reducing their hazardous environmental effects. When amount of methane gas production is enough to continuously combustion as Hasdal sites example, electric power generation is a considerable method for methane gas removal. On the other hand, if disposal site is restively small and methane gas production is not continuous, and methane concentrations are higher than flammable concentration like Yakacik disposal site, usage of intermittently combustion method without electric production is more reasonable. Intermittently combustion of methane would also suitable Hasdal disposal site when amount of methane is not enough to continuous combustion in the future.

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