

## INVESTIGATION AND EVALUATION OF H<sub>2</sub>S EMISSIONS FROM A MUNICIPAL LANDFILL

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*Submitted 18 Sept. 2008; accepted 22 Nov. 2010*

**Abstract.** The aim of investigation was to evaluate the degree of pollution caused by a municipal landfill and determine the dependence of the amounts of emissions of the odorant hydrogen sulphide (H<sub>2</sub>S) on different parameters of the environment. The Jerubaičiai landfill in Plungė district was selected for the investigation. Measurements were recorded at 59 points and 2 monitoring wells. The measurement points and places were selected so that the landfill places generating the largest amounts of H<sub>2</sub>S and the directions of pollutant movement are identified. It was determined that the amounts of H<sub>2</sub>S varied from 0.9 ppm (in February) to 8.6 ppm (in August) in different places of the landfill. The largest amounts of H<sub>2</sub>S were identified in the areas of freshly-tipped waste. Odorants in these zones are generated during waste tipping out of trucks or waste pushing. H<sub>2</sub>S generation in the top layer of waste changes during the day and different seasons of the year. It is mainly influenced by air temperature. No dependence between H<sub>2</sub>S generation velocity and air humidity or pressure was identified.

**Keywords:** municipal waste handling, landfill pollution, hydrogen sulphide, environmental conditions.

### 1. Introduction

Human activities are directly related to waste generation. With economic situation improving and consumption increasing, waste amounts are increasingly growing and the problem of waste disposal, consequently, becomes more and more urgent (Czepiel *et al.* 1996). The problem of waste disposal has not been completely dealt with in Lithuania. Upon installing regional landfills which meet the EU requirements, waste disposal in other landfills has been forbidden (Joseph, Price 1999). However, nearly all municipalities still have problematic landfills which negatively affect the environment due to leachate formation in them, pollutant emissions and odours as well as a negative effect on landscape (Venkatesan, Swaminathan 2009; Kvasauskas, Baltrėnas 2009). Still not long ago, before the EU-funded projects were launched, the total number of landfills in Lithuania was above 800. Only after Lithuania joined the EU, waste handling problems have received a more serious attention (Zigmontienė, Zuokaitė 2010).

A programme concerning the reorganisation of the waste sector, closure of old landfills and installation of new regional landfills has been implemented for nearly ten years in Lithuania. Consequently, it is important to evaluate the influence the waste handling sector has on environmental pollution, since landfills are among the largest sources of environmental pollution (Eitzer 1999; Jaskėlevičius, Lynikienė 2009). The aim of the investigation described in this paper is to evaluate the pollution generated by a municipal waste landfill, to analyse the emissions of the odorant hydrogen sulphide (H<sub>2</sub>S) from a

landfill operated according to all established requirements and to evaluate the dependence of pollutant generation on various environmental parameters.

The results of the investigation will serve as a basis for a theoretical evaluation of H<sub>2</sub>S generation amounts in other big regional landfills.

### 2. Methods

The Jerubaičiai landfill set up in Plungė district was chosen for the investigation. This choice was determined by the fact that it was the first landfill in Lithuania installed in observance of nearly all the requirements for landfill installation laid down by the EU and Lithuania and it receives only municipal waste. After its reorganisation in 2009, the Telšiai region municipal waste landfill was set up here.

A site for the landfill was selected back in 1998. As the region has implemented the system of waste collection in containers, waste from the entire region is disposed in the landfill. The site for the landfill was selected in an area of an even relief not far from the road Plungė-Mėdingėnai.

During site preparation for landfill installation the topsoil was removed.

Local soil was excavated to a depth of 2 m and was later used for road building or waste backfill. Another important circumstance – there are no residents in the protective area of the landfill. The locality concerned is surrounded by forests all around. A territory of 16 ha is allocated for the landfill, but waste, currently, is disposed only in part of this territory.

In 2008, when the investigation was carried out, the landfill was divided into 4 sections but only the 1<sup>st</sup> section was operated. Waste was landfilled in layers, 2.5 thick, and backfilled with soil, 20–25 cm. Landfill operation was started in 2001 and solely municipal waste was disposed there. Other wastes are sorted out in the neighbouring building. The amount of waste accumulated in the landfill reaches 14 900 cubic metres.

Prior to landfill installation, bores for the monitoring of groundwater quality were made. The performed geological investigations show that the clayey soil predominant in the locality and its filtration properties do not meet the requirements set for a natural clayey screen. Permeability of the brown clay predominant in the locality is around  $1 \times 10^{-7}$  m/s. Groundwater flows southward in the direction of the road Plungė-Medingėnai. The locality has all the required engineering systems, including those to lower a level of groundwater (ground water is 1 m below the locality's bottom screen), protective embankments against local soil all around, a HDPE layer, 2 mm thick, on the landfill's bottom which is protected by a sand layer of 30 cm thickness from underneath.

A leachate collection system is installed in the entire territory by mounting perforated PVC pipes. Each section is fitted up with gas-collection wells the height of which can be increased with the pile of waste in the landfill growing. Gravel roads for waste transport are built on the pile crests. Biological and chemical treatment ponds are installed for leachate treatment.

An on-site measurement technique was selected to identify the amount of hydrogen sulphide emissions from the landfill. This was determined by the conclusions of literature overview concerning hydrogen sulphide formation (Christophersen, Kjeldsen 1999; Farguhar, Rovers 1993; Termonia, A., Termonia, M. 1999; Maurice, Lagerkvist 1997).

When making on-site measurements, hydrogen sulphide emissions can be identified upon assessing the wind speed and hydrogen sulphide concentrations at different points of the landfill. This measurement technique boasts of the following advantages: representative emissions are obtained for individual parts of the landfill, continuous measurements within a longer period of time and at a different time of the day and seasons of the year are feasible and result interpretation is simple.

H<sub>2</sub>S emissions can be measured under such conditions which are required by the devices used. Hydrogen sulphide is a priority trace compound which can be quantified in the locality if its content is below 50 ppm. If its concentration is larger, a laboratory analysis is necessary for a more precise identification. Measurements were made with a manual hydrogen sulphide meter and the obtained results were recorded directly on the spot.

Simultaneously ambient air temperature and humidity were measured. Data about atmospheric pressure were obtained from a meteorological station located in Telšiai region.

*Measurement points.* Measurements were recorded at 59 points and 2 monitoring wells. This number of measurement points and their locations were selected with the aim of identifying the landfill zones, in which the largest amounts of hydrogen sulphide are generated, and determining the directions of H<sub>2</sub>S movement from the landfill.

The territory of the landfill's 1<sup>st</sup> section was divided into squares and measurements were made at their angles (Fig. 1). A square side was 15 m long (only in the northern part of the landfill it was 11 m long). All these measurement points were numbered from 1 (the northernmost) to 35. All the measurement points are indicated in the plan of the 1<sup>st</sup> section (Fig. 2).



Fig. 1. Jerubaičiai landfill

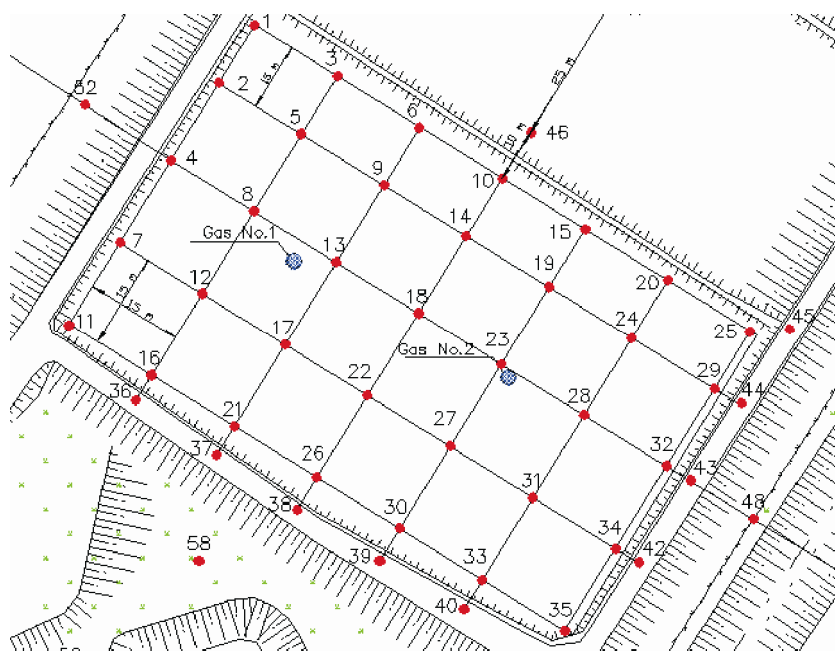


Fig. 2. Measurement points in the 1<sup>st</sup> section of Jerubaičiai landfill

Two additional measurement points (Gas No. 1 and Gas No. 2) were selected in the monitoring wells (Fig. 2) which have been installed since the very launch of the landfill. These points differ from the others as H<sub>2</sub>S amount generated in them significantly differs from that generated in the landfill's surface layer.

At the investigation points flow movement velocity and temperature were measured with the measuring instrument Testo 435.

Since it's a common knowledge that filtrate accumulation places is an additional source of H<sub>2</sub>S generation (James, Stack 1997; Allen *et al.* 1999; Hilger *et al.* 1999), measurements were taken nearby these places. Measurement points 35–45 were selected due to the fact that filtrate accumulation places were in close proximity to the landfill's 1<sup>st</sup> section. Emergence of such filtrate accumulation places resulted from inefficient functioning of the leachate collection system of the Jerubaičiai landfill prior to its reconstruction. Measurement points 58 and 59 are in close proximity to leachate biological treatment ponds. These points were selected for the same reason as points 36–45. Measurement points 46–54 are located outside the landfill. They are at a distance of 25, 50 and 100 m from the landfill operating section. Measurements at these points were made with the aim of comparing H<sub>2</sub>S amounts in close proximity to the landfill's territory eastwards, northwards and westwards. Measurement points 55, 56 and 57 are within the district of landfill service sector in which landfill operators spend most of their working hours.

Measurements were also made nearby the nearest dwellings with the aim of determining a potential impact of H<sub>2</sub>S on residents who live at a distance of 1 km from the landfill's territory.

*Measurement time and frequency.* The measurements were made with the aim of identifying changes in H<sub>2</sub>S amounts generated in the Jerubaičiai landfill within a

year. Thus, measurements were recorded during different times of the year (in August, November, February and April).

*Devices used for H<sub>2</sub>S measurements.* Hydrogen sulphide measurements can be performed with real-time analysers of different types. Such devices can identify hydrogen sulphide from 0.1 ppm to 50 ppm, which meets the characteristics of the majority of laboratory instruments. Measurements were made using a gas analyser GD/MG 7.

*Air humidity.* Operation of psychrometers is based on the principle of heat exchange. They determine relative humidity according to a difference in temperatures of dry and humidified thermometers. During this investigation air humidity was measured with an Asman psychrometer.

*Temperature and velocity measurement.* These measurements were made using an instrument Testo 435. It can calculate a flow volume (m<sup>3</sup>/h, m<sup>3</sup>/min, ...) by joining the thermal and vane anemometers advantages.

### 3. Results and discussions

Hydrogen sulphide emissions were analysed in different places of the landfill and during different seasons of the year. First, it should be noted that the recorded H<sub>2</sub>S amount at the same measurement points differs depending on the month of measurement (August, November, February and April). As recorded, H<sub>2</sub>S amount in August was by 2–3 ppm larger than in November and April, and by almost 5–6 ppm bigger against February. Similar results were obtained at nearly all the measurement points (Figs 3, 4).

The highest amount of H<sub>2</sub>S was recorded in a gas-monitoring well (Gas No. 2) where the average value was equal to 8.6 ppm in August, 8.1 ppm in November, 6.0 ppm in February and 7.3 ppm in April. The amount of

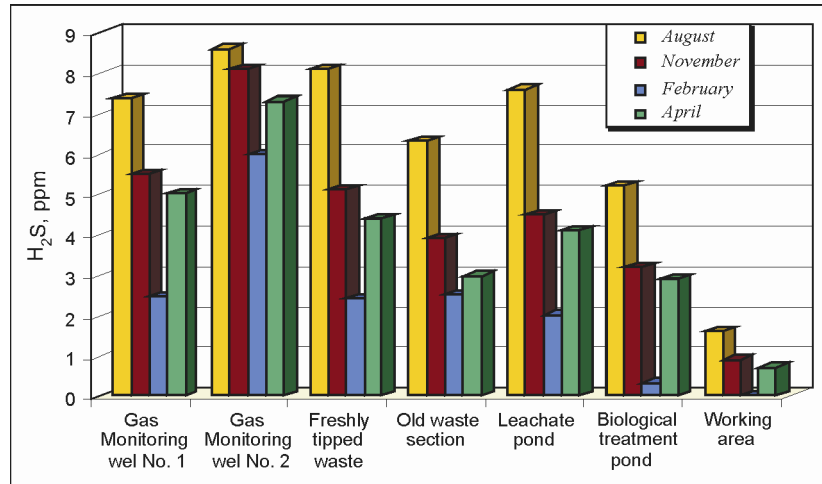


Fig. 3. H<sub>2</sub>S emissions (ppm) from different pollutant generation sources in the landfill

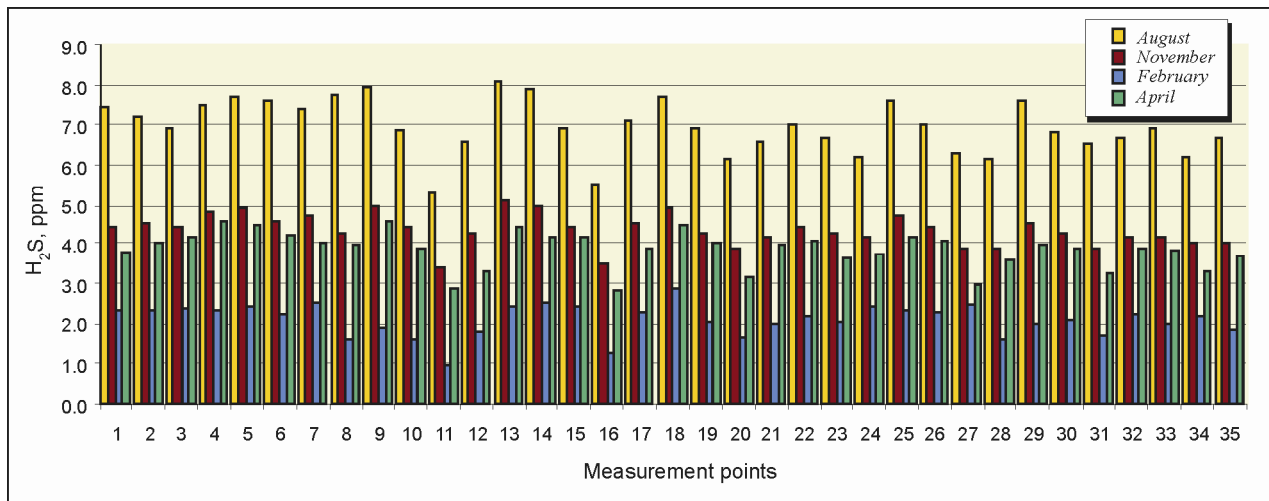


Fig. 4. Identified H<sub>2</sub>S values in Jerubaičiai landfill well No. 1

H<sub>2</sub>S identified at this monitoring point in August was by a mere 2.6 ppm larger than that determined in November. Such a value of H<sub>2</sub>S can be explained by the fact that this monitoring well was made at the beginning of the landfill operation. It reaches those layers of waste which were landfilled 3–4 years ago. This amount of H<sub>2</sub>S is generated from the waste disposed at a depth of 10 metres and the temperature there essentially differs from that on the landfill’s surface.

Gas-monitoring well No. 1 was also equipped at the beginning of landfill operation but it is in the landfill section which is currently operated. It reaches those layers of waste which were landfilled before 1–2 years and are currently at a depth of 3–4 metres. H<sub>2</sub>S amount at this point, therefore, differs depending on the season of the year. H<sub>2</sub>S generation at this measurement point (like in the others) depends on meteorological conditions. The largest amount is generated in August (7.6 ppm), while the least – in February (2.6 ppm). These months represent the seasons of the year with completely different climatic conditions. The amount of H<sub>2</sub>S identified in November and April was equal to 5.5 ppm and 5 ppm, respectively.

H<sub>2</sub>S concentration identified nearby biological treatment ponds was equal to 5.2 ppm in August, 3.2 ppm in November, 0.3 ppm in February and 2.9 ppm in April. Here pollutants are spreading due to odorant emissions from leachate accumulation places. The same explanation applies when analysing H<sub>2</sub>S amounts generated close to filtrate accumulation places nearby the landfill’s 1<sup>st</sup> section. H<sub>2</sub>S amounts recorded here are: 7.6 ppm in August, 4.5 ppm in November, 2.0 ppm in February and 4.1 ppm in April.

H<sub>2</sub>S concentrations determined in the zone in which the landfill operators spend most of their working time are: 1.6 ppm in August, 0.9 ppm in November and 0.7 ppm in April. No. H<sub>2</sub>S was identified during the February measurements.

Measurements in the landfill’s 1<sup>st</sup> section were made at 35 points. H<sub>2</sub>S values vary from 8.1 ppm in August and 5.1 ppm in November to 6.1 ppm in August and 3.9 ppm in November (Fig. 5).

The highest value of H<sub>2</sub>S was established at measurement points 13, 14 and 9, which are in close proximity to a fresh waste-tipping area. Here, H<sub>2</sub>S concentration

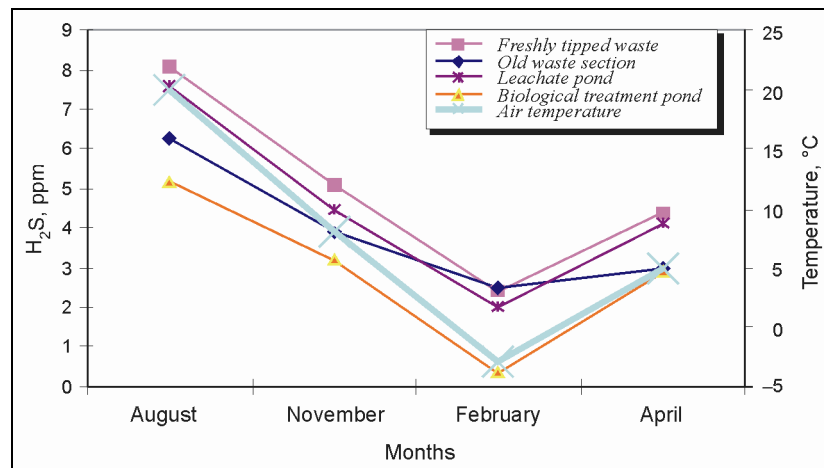


Fig. 5. H<sub>2</sub>S concentration dependence on air temperature

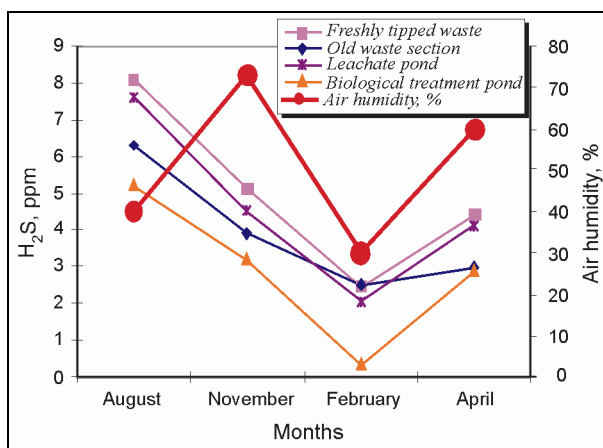


Fig. 6. H<sub>2</sub>S concentration dependence on air humidity

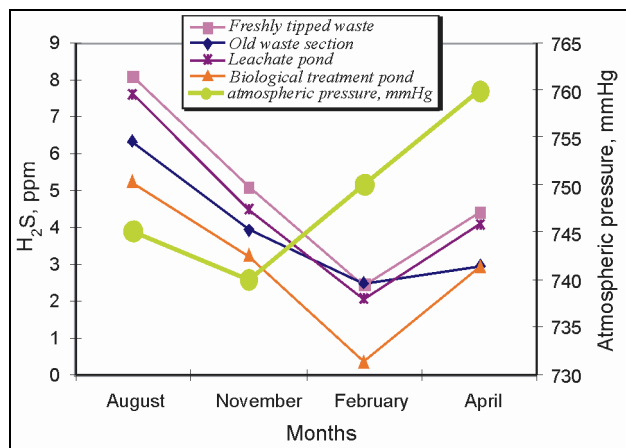


Fig. 7. H<sub>2</sub>S concentration dependence on atmospheric pressure

was equal to 8.1 ppm in August, 5.1 ppm in November, 2.4 ppm in February and 4.4 ppm in April. In this part of the landfill odorants are mainly generated during waste tipping out of trucks and waste pushing.

The lowest amounts of H<sub>2</sub>S were determined in measurement points 11 and 16 (approximately 5 ppm in August, 3 ppm in November, 1.1 ppm in February and 2.8 ppm in April). The thickness of a waste layer in these parts of the landfill reaches around 0.3 metre. Also, no leachate accumulations are present here. The biggest and the smallest amounts differ by a mere 2–3 ppm.

Attention should be paid to measurement points 31, 28 and 24, in which H<sub>2</sub>S amount was equal to 6.5 ppm, 6.1 ppm and 6.2 ppm in August, 3.9 ppm and 4.2 ppm in November, 1.7 ppm, 1.6 ppm and 2.4 ppm in February, and 3.2 ppm, 3.6 ppm and 3.8 ppm in April, respectively. This section of the landfill has accumulated old waste, from 3 to 2 years old. During the investigation this section was not operated; consequently, H<sub>2</sub>S was emitted only by old waste.

Measurement points 22, 18 and 14 are within the landfill's territory not far from a compactor operation zone. Here H<sub>2</sub>S amount was by around 1 ppm higher compared to the old waste zone and reached 7 ppm in

August, 4.4 ppm in November, 2.9 ppm in February and 4.5 ppm in April.

Measurement points 33, 35 and 32 and 34 are on the edge of the landfill pile, but H<sub>2</sub>S amount at these points reaches 7 ppm in August, 4.2 ppm in November, 1.8 ppm in February and 3.7 ppm in April, showing nearly the same values as pollutant concentrations by the compactor operation zone. Such H<sub>2</sub>S amounts can be explained by a close proximity of leachate accumulation places to these points.

These results show that meteorological conditions are one of the major factors determining H<sub>2</sub>S generation in the landfill. Characteristics of meteorological parameters are presented in Table 1.

The influence of ambient parameters (temperature, air humidity and atmospheric pressure) on H<sub>2</sub>S generation is shown in Figs 5, 6 and 7. These figures show H<sub>2</sub>S concentration in different sections of the landfill.

Table 1. Meteorological parameters

Parameters	August	November	February	April
Air temperature, °C	+20	+8	-3	+5
Air humidity, %	40	73	30	60
Atmospheric pressure, mmHg	745	740	750	760

During the investigation the highest temperature was in August (+20 °C), while the lowest in February (−3 °C). In November air temperature was by around 12 °C lower than in August and H<sub>2</sub>S amount during these months differs by almost 3.5 ppm. From February air temperature was rising and reached 5 °C in April. H<sub>2</sub>S amount was changing accordingly. The difference between H<sub>2</sub>S amounts in February and April is 2–3 ppm. H<sub>2</sub>S amount generated from freshly-landfilled waste in particular depends on the temperature of ambient air as shown in Fig. 5.

The investigation aimed to determine whether air humidity and atmospheric pressure have a similar influence on H<sub>2</sub>S generation as air temperature does. The highest air humidity was recorded in November with H<sub>2</sub>S generation being low. The lowest air humidity, as well as the lowest H<sub>2</sub>S amount, was recorded in February.

A similar situation is with regard to H<sub>2</sub>S amount dependence on atmospheric pressure. The atmospheric pressure recorded in August was higher than in November (like the amount of H<sub>2</sub>S), but lower than in February and April. As mentioned before, H<sub>2</sub>S amount fluctuated unevenly over these months. Results presented in Figs 6 and 7 clearly show that no dependence of H<sub>2</sub>S generation in the landfill on air humidity or atmospheric pressure is present.

Measurements during the day were made in the most polluted point. These results of H<sub>2</sub>S generation during the day and different seasons of the year at measurement point Gas No. 1 are presented in Fig. 8.

In the morning (at 8:00), H<sub>2</sub>S content is the lowest during the day and is equal to 7.4 ppm in August, 5.4 ppm in November 1.9 ppm in February and 3.8 ppm in April. A more significant increase in H<sub>2</sub>S emissions

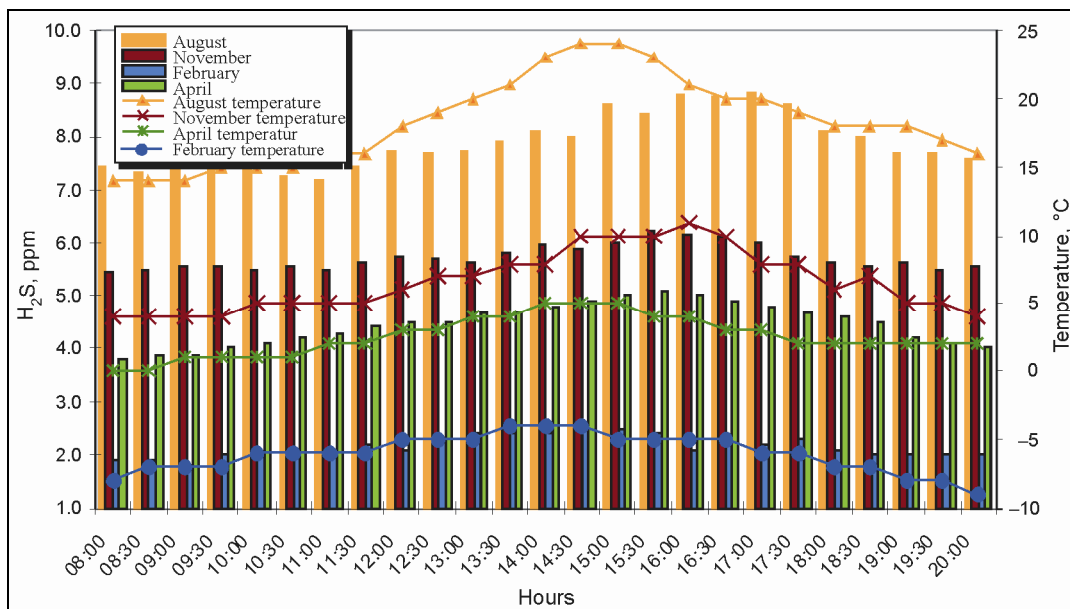


Fig. 8. H<sub>2</sub>S change during the day (point Gas No. 1)

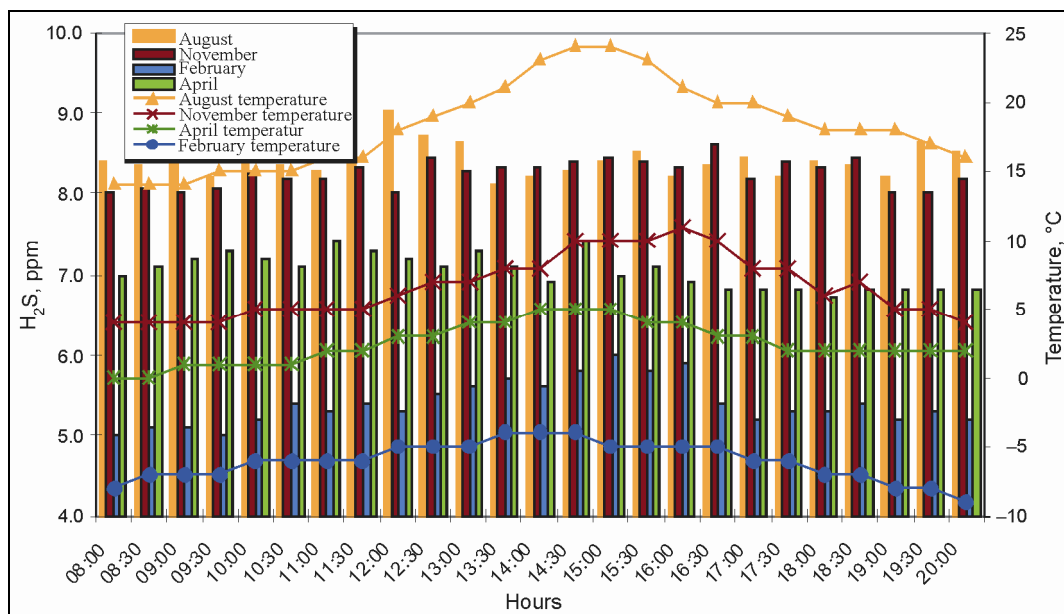


Fig. 9. H<sub>2</sub>S change during the day (point Gas No. 2)



was recorded at 12:00 when the peak was reached (8.8 ppm in August, 6.2 ppm in November, 2.5 ppm in February and 5.1 ppm in April). As the results presented in this Figure show, the highest H<sub>2</sub>S emissions are in the daytime from 14:30 to 17:30 during any season of the year. From 18:00 H<sub>2</sub>S emissions start decreasing and at 20:00 reach 7.6 ppm in August, 5.6 ppm in November, 2 ppm in February and 4 ppm in April.

Similar air temperature variation occurs during the day. At the time of measurement it was the lowest in the morning at 8:00 (+14 °C in August, +4 °C in November, -8 °C in February and 0 °C in April), while the highest at 14:30 (+24 °C in August, +10 °C in November, -4 °C in

February and +5 °C in April). Later, at 20:00, temperature started falling to +16 °C in August, +4 °C in November, -9 °C in February and +2 °C in April. These results allow to draw a conclusion that H<sub>2</sub>S generation in the daytime is directly dependent on ambient air temperature.

The results of H<sub>2</sub>S generation during the day and different seasons of the year at measurement point Gas No. 2 are presented in Fig. 9.

H<sub>2</sub>S amounts generated in monitoring well Gas No. 2 vary during the day and different seasons of the year. During measurements made in August the largest amount of H<sub>2</sub>S (9 ppm) was identified at 12:00, while the lowest (7.3 ppm) – at 9:30 and 16:00. In November the

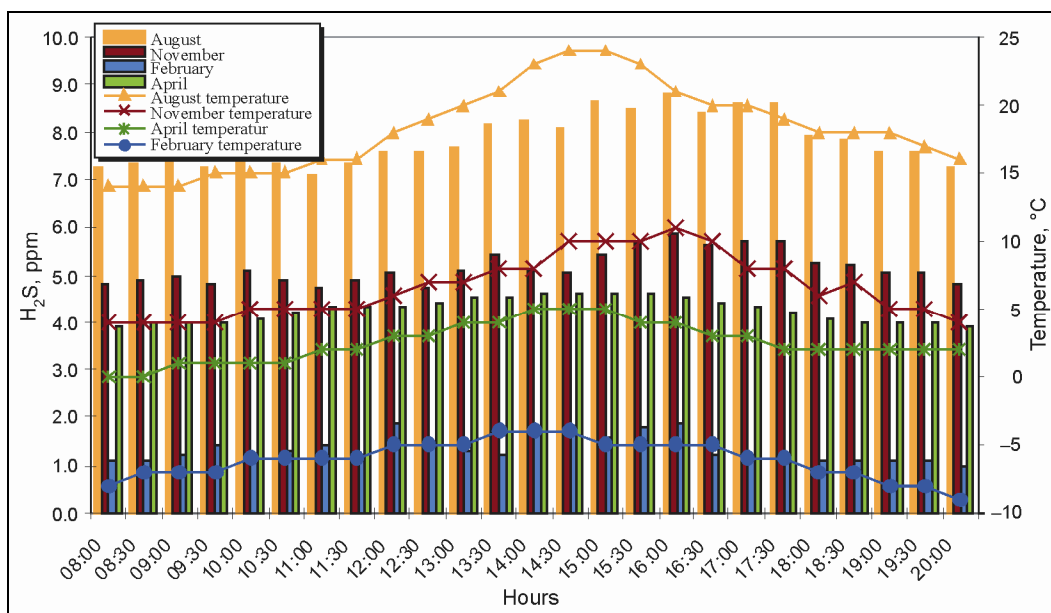


Fig. 10. H<sub>2</sub>S change during the day (point No. 9)

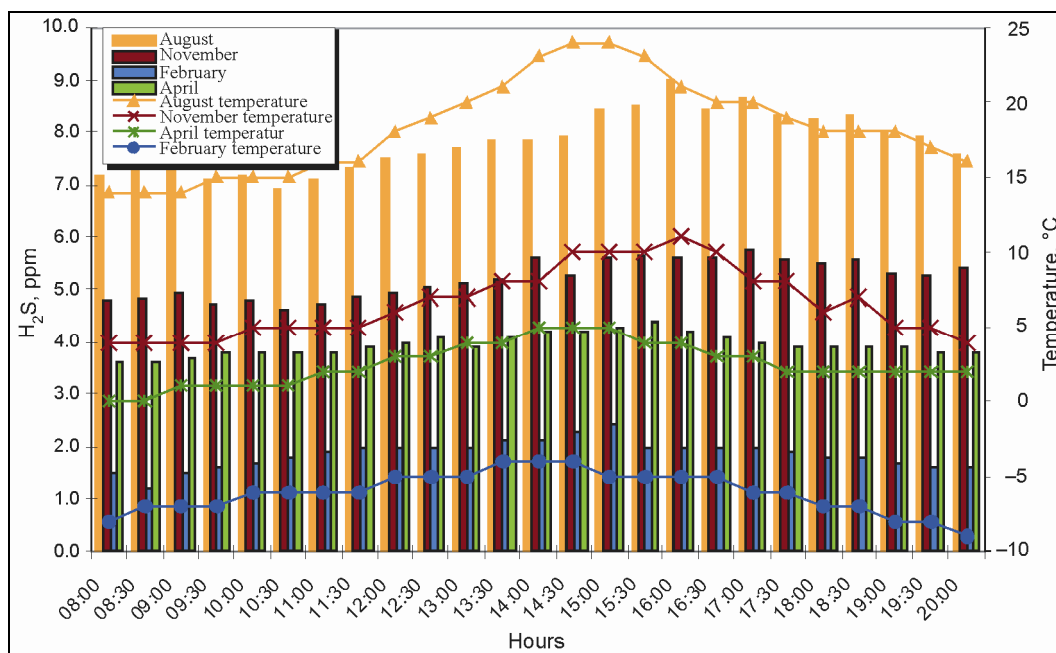


Fig. 11. H<sub>2</sub>S change during the day (point No. 13)

biggest content of H<sub>2</sub>S (8.6 ppm) was established at 16:30 and 18:30, in April – at 14:30 (7.4 ppm). In the meantime the lowest content of H<sub>2</sub>S (8 ppm) was recorded at 12:00 in November and 16:30 (6.8 ppm) in April.

The dependence of H<sub>2</sub>S amount on the time of the day was determined only during the daytime measurements made in February. In the morning (at 8:00) H<sub>2</sub>S amount was the lowest equal to 5 ppm. H<sub>2</sub>S amount started increasing up to 5.5 ppm from 12:00 and reached the peak (5.9 ppm) at 16:00. The amount of subsequently generating H<sub>2</sub>S starts decreasing and reaches 5.2 ppm at 8:00.

These results allow to draw a conclusion that H<sub>2</sub>S generation at measurement point Gas No. 2 does not depend on the time of the day or ambient air temperature, except for the winter.

Measurements during the day were also made at other points in which the highest concentration of H<sub>2</sub>S was recorded. Change in H<sub>2</sub>S concentrations during the day and different time of the year at measurement point 9 is presented in Fig. 10. In the morning (at 8:00), H<sub>2</sub>S content is the lowest and is equal to 7.3 ppm in August, 4.8 ppm in November 1.1 ppm in February and 3.9 ppm in April. From 12:00 H<sub>2</sub>S emissions start increasing and reach the peak (8.8 ppm in August, 5.9 ppm in November, 2.4 ppm in February and 4.6 ppm in April). As the results presented in this Figure show, the highest amounts of H<sub>2</sub>S are identified between 14:30 and 17:30 during any season of the year. From 18:00 H<sub>2</sub>S concentration starts decreasing and at 20:00 reaches 7.3 ppm in August, 4.8 ppm in November, 1.0 ppm in February and 3.9 ppm in April.

Change in H<sub>2</sub>S concentrations during the day and different time of the year at measurement point 13 is presented in Fig. 11.

H<sub>2</sub>S concentration determined in the morning (at 8:00) was the lowest during the measurements and reached 7.2 ppm in August, 4.8 ppm in November, 1.5 ppm in February and 3.6 ppm in April. From 12:00 H<sub>2</sub>S emissions start increasing and reach the peak (9.0 ppm in August, 5.8 ppm in November, 2.4 ppm in February and 4.2 ppm in April). As the results presented in this Figure show, the highest amounts of H<sub>2</sub>S are identified between 14:30 and 17:30 during any season of the year. From 18:00 H<sub>2</sub>S concentration starts decreasing and at 20:00 reaches 7.6 ppm in August, 5.4 ppm in November, 1.6 ppm in February and 3.8 ppm in April.

The results presented in Figs. 8 and 11 allow to draw a conclusion that the emissions of H<sub>2</sub>S from the surface layer of waste change during the day within the limits of 1–1.5 ppm. The intensity of pollutant emission is directly dependent on ambient air temperature.

The measurements of H<sub>2</sub>S concentrations were made in close proximity to the nearest dwellings (at a distance of nearly 1 km from the landfill territory). The instrument GD/MG 7 did not detect any trace of H<sub>2</sub>S during any season of the year.

The measurements, which were performed at distances of 25, 50 and 100 metres from the landfill showed

only trace of H<sub>2</sub>S: The concentrations reached 0–1 ppm during any season of the year.

#### 4. Conclusions

1. Considering the fact that the amount of hydrogen sulphide generated in a landfill is directly dependent on ambient parameters, an on-site measurement technique was selected. In order to identify the changes of H<sub>2</sub>S emissions generated in a landfill more precisely, measurements were made during the day and different time of the year (in August, November, February and April).

2. As determined during the measurements performed in August, November, February and April, the concentration of hydrogen sulphide at the same measurement points was different. H<sub>2</sub>S concentration at nearly all the measurement points in August was by 2–3 ppm higher than in November and April, and by almost 5–6 ppm bigger than in February.

3. It was determined that H<sub>2</sub>S concentration varied from 0.9 ppm (in February) to 8.6 ppm (in August) in different zones of the landfill. The highest concentration of H<sub>2</sub>S was established at measurement points 13, 14 and 9, which are in close proximity to the fresh waste tipping area. Here, H<sub>2</sub>S emissions are generated during waste-tipping out of trucks and waste pushing. The lowest concentration of H<sub>2</sub>S was determined at measurement points 11 and 16 (around 5 ppm in August, 3 ppm in November, 1.1 ppm in February and 2.8 ppm in April). Waste thickness in this zone of the landfill reaches only around 0.3 m.

4. H<sub>2</sub>S concentration in a gas-monitoring well (Gas No. 2) in August was by a mere 2.6 ppm higher than that recorded in February. Such a minor change in H<sub>2</sub>S concentration can be explained by the fact that this monitoring well reaches waste which has been lying deep for already 3–4 years. H<sub>2</sub>S emission at such a depth only insignificantly depends on ambient air temperature.

5. H<sub>2</sub>S emissions from the surface layer of waste change during the day and different seasons of the year. Ambient air temperature is the main parameter having a direct influence on H<sub>2</sub>S emissions. In the meantime no dependence of H<sub>2</sub>S emissions on relative humidity or atmospheric pressure was determined.

#### References

- Allen, M. R.; Braithwaite, A.; Hills, C. C. 1999. Trace organic compounds in landfill gas at seven U.K. waste disposal sites, *Environmental Science and Technology* 31: 106.
- Christophersen, M.; Kjeldsen, P. 1999. Field investigations of lateral gas migration and subsequent emission at an old landfill, in *Sardinia 99 Seventh International Waste Management and Landfill Symposium*, 4–8 October 1999, Cagliari, Italy, IV: 79–86.
- Czepiel, P. M., *et al.* 1996. Landfill methane emissions measured by enclosure and atmospheric tracer methods, *Journal of Geophysical Research* 101: 169. doi:10.1029/96JD00864
- Eitzer, B. D. 1999. Emissions of volatile organic chemicals from municipal solid waste composting facilities, *Environ. Sci. Technology* 29: 902.



- Farguhar, G. J.; Rovers, F. A. 1993. *Gas production during refuse decomposition, Water, Air and Soil Pollution*. Vol. 2. 156 p.
- Hilger, H. A.; Liehr, S. K.; Barlaz, M. A. 1999. A model to assess biofilm exopolymer effects on methane oxidation in landfill cover soil, in *Sardinia 99 Seventh International Waste Management and Landfill Symposium*, 4–8 October 1999, Cagliari, Italy, III: 411–417.
- James, K. J.; Stack, M. A. 1997. The impact of leachate collection on air quality in landfills, *Chemosphere* 34: 721. doi:10.1016/S0045-6535(97)00028-3
- Jaskelevičius, B.; Lynikienė, V. 2009. Investigation of influence of Lapės landfill leachate on ground and surface water pollution with heavy metals, *Journal of Environmental Engineering and Landscape Management* 17(3): 131–139. doi:10.3846/1648-6897.2009.17.131-139
- Joseph, J. B.; Price, J. L. 1999. Implementation of the landfill directive: future perspective for policy and decision makers, in *Proceedings Sardinia 99, Seventh Landfill Symposium*. CISA publisher, Cagliari, vol. IV: 271–277.
- Kvasauskas, M.; Baltrėnas, P. 2009. Research on anaerobically treated organic waste suitability for soil fertilisation, *Journal of Environmental Engineering and Landscape Management* 17(4): 205–211. doi:10.3846/1648-6897.2009.17.205-211
- Maurice, C.; Lagerkvist, A. 1997. Seasonal influences of landfill gas emissions, in *Sardinia 97 Sixth International Landfill Symposium*, 13–17 October 1997, Cagliari, Italy, IV: 87–94.
- Termonia, A.; Termonia, M. 1999. Characterisation and on-site monitoring of odorous organic compounds in the environment of a landfill site, *Intern. J. Environ. Anal. Chem.* 73(1): 43–57. doi:10.1080/03067319908032650
- Venkatesan, G.; Swaminathan, G. 2009. Review of chloride and sulphate attenuation in ground water nearby solid-waste landfill sites, *Journal of Environmental Engineering and Landscape Management* 17(1): 1a–1g.
- Zigmontienė, A.; Zuokaitė, E. 2010. Investigation into Emissions of Gaseous Pollutants during Sewage Sludge Composting with Wood Waste, *Journal of Environmental Engineering and Landscape Management* 18(2): 128–136. doi:10.3846/jeelm.2010.15

## SIEROS VANDENILIO IŠSISKYRIMO KOMUNALINIŲ ATLIEKŲ SAVARTYNE TYRIMAI IR ĮVERTINIMAS

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Santrauka

Tyrimų tikslas buvo įvertinti komunalinių atliekų savartyno skleidžiamą taršą ir nustatyti išsiskiriančio odoranto sieros vandenilio (H<sub>2</sub>S) kiekių priklausomumą nuo įvairių aplinkos parametrų. Tyrimams buvo pasirinktas Jerubaičių savartynas Plungės rajone. Matavimai atlikti 59 taškuose ir dviejuose monitoringo šuliniuose. Matavimo taškai ir vietos pasirinkta daugiausia H<sub>2</sub>S generuojančioms savartyno vietoms bei teršalų judėjimo kryptims nustatyti. Nustatyta, kad įvairiose savartyno vietose H<sub>2</sub>S kiekiai kinta nuo 0,9 ppm (vasario mėn.) iki 8,6 ppm (rugpjūčio mėn.). Didžiausi H<sub>2</sub>S kiekiai rasti ten, kur išpilamos naujai atvežamos atliekos. Šiose zonose odorantai išsiskiria sunkvežimiams išpilant atliekas ir jas stumdant. Per dieną ir įvairiais metų laikais viršutiniame atliekų sluoksnyje susidaro nevienodi H<sub>2</sub>S kiekiai. Didžiausią įtaką turi oro temperatūra. Priklausomybių tarp H<sub>2</sub>S susidarymo greičio ir oro drėgmės bei slėgio nenustatyta.

**Reikšminiai žodžiai:** komunalinių atliekų tvarkymas, savartyno skleidžiama tarša, sieros vandenilis, aplinkos sąlygos.

## ИССЛЕДОВАНИЯ ПО ОЦЕНКЕ ВЫБРОСОВ СЕРНИСТОГО ВОДОРОДА НА СВАЛКЕ МУНИЦИПАЛЬНЫХ ОТХОДОВ

С. Васаревичюс

Резюме

Целью исследования было оценить загрязнение окружающей среды, вызываемое муниципальными отходами на свалке, и определить зависимость количества выбрасываемого сернистого водорода (H<sub>2</sub>S) от условий окружающей среды. Исследования проводились на свалке Йерубайчай в районе Плунге. Измерения проводились в 59 точках и 2 колодцах мониторинга. Точки для измерений были подобраны таким образом, чтобы выявить зоны свалки с наибольшим количеством выбросов H<sub>2</sub>S. В ходе исследования установлено, что количество H<sub>2</sub>S меняется от 0,9 ppm (в феврале) до 8,6 ppm (в августе). Наибольшие количества H<sub>2</sub>S найдены в местах выгрузки привозимых отходов. Выделение H<sub>2</sub>S из верхнего слоя отходов меняется в течение дня и в разное время года. Наибольшее влияние на выделение H<sub>2</sub>S оказывает температура воздуха. Зависимости между количеством выбрасываемого H<sub>2</sub>S и относительной влажностью или давлением воздуха не установлено.

**Ключевые слова:** менеджмент муниципальных отходов, эмиссии загрязняющих веществ со свалок, сернистый водород, условия окружающей среды.

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