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The Safety Situation of Municipal Solid Waste Landfills in Hungary from a Disaster Management Perspective – Part 2

Abstract

Today, nearly seventy municipal solid waste landfills in Hungary fully comply with European Union directives. Experience has shown that some sites have not yet been recultivated and that there are several illegal landfills. Waste fires are a special area within disaster management that have not yet been legally regulated nor intervention procedures have been established. In the second half of the series of articles I will present the safety risks and fire intervention difficulties that arise specifically in connection with the landfill sites.

Keywords: waste management, resource management, extinguishing water management, fire safety, industrial safety

Introduction

The issue of fire safety and emergency planning of municipal solid waste storages (hereinafter: landfills) in Hungary is a less scientifically researched topic. Waste is inherent in human life. No waste is generated in nature, as any residue is recovered in the form of food or humus. In some cases, it can also serve as a habitat for smaller organisms. However, mankind has been producing unusable materials since the beginning of his evolutionary development.

In the previous part of the series of articles, I dealt with the conceptual interpretation of residential solid waste (hereinafter: waste), the domestic composition of waste generation, as well as the international and domestic legal regulation of

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waste management and its implementation practice. In the second part of the article, I presented the sources of danger of landfills, the circumstances of the intervention and its hindering factors. In this article, the economic aspects of waste fires are discussed from the point of view of disaster management. I will also deal with the analysis of the characteristics of fires occurring in the area of landfills, the scope of problems and detection possibilities of underground fire spread, as well as the possibilities of investigating the release of environmental pollutants generated during fires. At the end of the investigations presented above, I will analyse the safety issues and problems of firefighting interventions in the area of landfill sites.

Evaluation of the economic aspects of fire interventions in the area of landfill sites

One of the prominent common characteristics of fires that occur at landfills is that there is no longer any salvage of value during fires. As a result, during the intervention in the case of a fire in the area of landfill, two objectives prevail: minimising the emission of environmental pollutants and maintaining the operation of the landfill.

An important objective is also to reduce the environmental pollution released into the air during combustion, and entering the soil and groundwater with the extinguishing firewater, as well as guaranteeing the safe operation of the landfill as a kind of critical infrastructure element. Unfortunately, however, the waste management sector is not currently considered a critical infrastructure system in Hungary. In Hungary, this issue is fully regulated by Government Decree 292/2013 (VII.26.) on the rules for non-regular waste transport and the designation of public bodies acting in this regard. In case of supply difficulties, on the basis of the above mentioned regulation, if the competent waste disposal company is unable to transport the waste from a given service area, the competent local authority of disaster management shall nominate another economic organisation in accordance with the legal regulations.

During the landfill fire, value is not saved, but the examination of the cost implications of the fire intervention does arise as an important factor. The cost of extinguishing water, possibly used fire extinguishing foaming material, fuel and the combined cost of the working hours of those involved in firefighting also arise as cost factors. During firefighting interventions, the main professional aspect is the most efficient and quick firefighting interventions, where the additional costs of the activities of disaster management organisations also arise. Currently, no national statistics are known in our country that would give a clear picture of the amount of waste landfill fires caused intentionally or carelessly in a given year, as well as their total costs. The question arises whether it is necessary to install fire protection forecasting and monitoring systems in the areas of waste disposal or processing facilities. It is likely that the vast majority of damage events requiring intervention lasting several hours or days are caused by the burning of waste disposal sites.

I agree with the opinion of József Padányi, according to which "the measurable loss in human lives can be continuously reduced thanks to the ever-increasing forecasting

tools".[2] Of course, this expert opinion is true not only for predicting natural, but also industrial hazards.

In my opinion, the investigation of fires related to residential waste for economic purposes may be justified, which is supported by the opinions of the experts I interviewed.

Investigation of fires occurring at municipal solid waste storages

Based on the previously examined aspects, it can be seen that fires occurring in the area of waste disposal sites can be considered an everyday phenomenon. In terms of nature, waste fires involve conditions similar to wildfires,[3] with the difference that in the case of the latter, we also have to account for value savings. It is therefore in my opinion worth showing the differences between the two events in a table:

Table 1: Firefighting tactics comparison of waste and wildfires

Evaluation criteria	Waste fire	Wildfire
Value saving	There is no value saving.	Possible value saving (for example endangering agricultural areas).
Accessibility	Accessible only on designated roads.	Generally, it is easily accessible by several road routes.
Terrain conditions	Typically, highly divided terrain conditions, where steep slopes are also common.	Generally uniformly flat or slightly uphill/sloping terrain.
Treating hot spots	Hot spots are difficult to access, turning over the material is a key issue.	The terrain is generally easy to navigate, and a flame arrester proves to be an effective tool.
Intervention with water	The material is highly waterproof, the water does not flow, or only with difficulty, and can leak only minimally.	Dry soil absorbs water well, it is difficult to soak the ground (except in the case of peat).
Usage of solid water stream	Solid water stream cannot handle hot spots.	Solid water stream does not cause any significant additional problems.
Potential fire extinguishing materials	It can be extinguished with water, foam and manual power also.	Water and dry methods are both applicable.
Risk of re-ignition	Even an area thought to have been extinguished can re-ignite.	An area that has already been burned down rarely catches fire again.
Necessary equipment	Usage of local heavy-duty machines is necessary in almost all cases.	The majority of cases can be handled with the standardised firefighting equipment.

[2] Padányi 2022: 20.
[3] Nagy 2015: 135.

Evaluation criteria	Waste fire	Wildfire
Vertical spread of the fire	Hot spots can also occur in the deeper layers of the landfill.	Combustion occurs only above ground level, and the probability of the occurrence of hot spots can be considered minimal.
Possibility of fire spread	Smoke does not always come from where the hot spot is.	When the fire burns with a flame, it can be localised well.
Special fire extinguishing features	In particular, the hot spots must be eliminated by turning over the waste.	The fire can also be extinguished with a flamethrower (usage of flame arrester). The fire can be extinguished by itself.
Presence of combustible material	The amount of combustible material is significant both horizontally and vertically.	In case of an open wildfire, only the horizontal spread of the fire can be clearly defined. Canopy fire also occurs in forested terrain.
Water supply	The water supply can be solved with a shuttle or from a local fire water reservoir of the landfill site. The scope of the working area is considered limited.	The water supply can be solved with a shuttle or suction of the water. A large working area is available for several vehicles.
Water sources	A nearby fire hydrant or fire water pool is a requirement.	There is no fire hydrant, or it is typically located at a great distance.
Other sources of hazards	In addition to mechanical damage, there is also a risk of infection.	Similar injuries are not typical.
Respiratory protection	Low-level respiratory protection may be obligatory, such as a work mask or a protective mask with a filter insert.	Respiratory protection is typically not obligatory.
Influence of environmental factors	The occurrence of landfill fires does not depend on the season, but warm weather increases the number of cases.	Typically in the period of warm and dry months.

Source: Compiled by the author.

Waste fires have many specifics that are not typical in any other type of disaster area. In the case of the influence of environmental factors, we can say that approximately one third of spontaneous combustion events can be related to the hot weather conditions.[4]

In the following, I will examine the issue of extinguishing water management in more detailed manner. Firefighters often make mistakes when they use firefighting tactics that are commonly used in case of wildfires. In the long term, excessive use of extinguishing water can unfortunately cause more problems than benefits. Hot spots occur mainly in the deeper layers, where an anaerobic condition does not yet exist. In this way, the material present in the landfill must be rotated in order to eliminate the hot spots. In many cases, firefighters prefer to "break up" hard-to-reach areas with a solid stream. Due to the heterogeneous composition of the waste, the extinguishing water injected in this way does not always exert its effect where it is directed. The material deposited in the landfill drains the water on the surface, so the

[4] Ibrahim et al. 2010: 737.

extinguishing water does not always reach the hot spots situated in deeper layers. As a result, the access roads can become impassable, which makes it necessary to use the grapple machine. The grapple machine can only be used during working hours. The on-call service of the machine operator is only available in a few landfill sites.

It is an essential issue to deliver the extinguishing water as and where it is needed. In the last century, a so-called coal jet pipe was used to extinguish, for example, haystacks and burning piles of coal. Nowadays, the same could be done with a water mist lance, which is not yet applied in Hungary. The sprayed water jet formed by the water mist lance works on the principle of inhibition, during which the water molecules are able to integrate into the chain of combustion and effectively extinguish the fire.[5]

The most critical area for landfill fires is the side of the landfill, where no compression procedure is applied, so movement on it is particularly dangerous. At this location the vertical fire spread can develop quickly due to the loose material structure. At the same time, due to the large distances, the water mist lance devices become useless. Therefore, the only possibility is the application of the solid stream, during which the problems already examined may appear. In such situations, the bucket of the grappler can typically help to turn over the hot spots. In order to solve this situation, it would be advisable to try a pair of fork-shaped mist lances that can be attached to the place of the grab bucket, which, in my opinion, could be suitable at the same time for injecting the extinguishing water and turning over the waste material to be extinguished. This would make the area accessible, and the side of the landfill would not get wet either. In case of landfill-side fires, it can also be a source of danger if the pipelines extracting landfill gas are damaged.

Some researchers are on the opinion to prioritise covering with earth (i.e. oxygen deprivation) over extinguishing waste fires. According to Ágnes Sallay's opinion, after covering of the landfill surface, the materials present in the area affected by the fire should be turned over and the smouldering parts should be extinguished with water, and then spread thinly.[6] The author recommends reducing the use of extinguishing water because organic waste increases gas production and the watery environment provides an ideal breeding ground for the growth of decomposition bacteria. At the same time, she draws attention to the fact that it is necessary to monitor the affected area for another two days. However, it is worth noting here that multi-day follow-up care of firefighters involves significant personal and financial resources. So, in this expert opinion, instead of fire protection and economic issues, environmental protection aspects better prevail. When discussing the issue of environmental pollution, the effects of climate change must be addressed, which can also promote the development of landfill fires as a result of dry weather conditions.[7]

[5] Kuti 2015: 262.
[6] Sallay 2003: 31.
[7] Rácz–Lóderer 2011: 91–98.

Prevention of underground fire spread and examination of its causes

In an international context, it is a frequently occurring problem that in the deeper layers of the landfill, ignition can occur as a result of surface fire spread or self-ignition. This phenomenon can occur due to the accumulation of landfill gases and the development of heat from decomposing materials,[8] or due to damage to the lithium-ion batteries. In such cases, the waste does not enter a completely anaerobic environment, as the recultivation by partial clay or earth covering has not yet taken place. As a result, the hearth of fire can produce a significant amount of smoke and consumes oxygen-rich air.[9] In these cases, the use of conventional detection methods, such as scanning with a thermal camera does not lead to results, as it can only detect surface infrared signal emission.

Foreign examples show that there are no effective methods in the field of intervention, as there are also cases where the waste glow lasts for several months.[10] In the case referred to in the example, similarly to the cases in Italy, the intervention was also delayed due to jurisdictional and legal disputes. In my opinion, if it had been possible to localise the fire when it started, the fire could have been extinguished in less time. Due to several months of inactivity, the fire spread to the entire area of the landfill. The maintenance of the fire was even more facilitated by surface land cultivation and disturbance of surface waste glows. The toxic combustion products produced during a fire also make the work conditions difficult. Another problem is that illegally created landfill sites are located mainly close to residential areas. It is therefore an important lesson for the authorities to take timely inspection actions when they experience illegal waste disposal activities.

Currently, two technical methods are known, which can be used for prevention and monitoring the extent of underground fires. The first is a classic remote sensing method, with which we can examine the fluctuation of heat and the heat emission of individual areas using a raster.[11] The other is a drilling method, with which we install pipelines through the layers of waste in a similar way to underground monitoring wells and examine the presence and concentration of evaporating toxic and flammable gases, with particular attention to combustion products.[12] This method is very similar to the already mentioned vertical landfill gas drainage. It can be concluded that it is also possible to inject extinguishing water through the pipelines. During the later gas concentration measurements, it can be established whether the fire has gone out or whether there is still a waste glow in the internal waste layers of the landfill.

[8] Chavan et al. 2019: 123.
[9] Molnár 2016: 80.
[10] CBS46 Atlanta: *Landfill fire still burns after 7 months.*
[11] Nazari et al. 2020.
[12] Sabrin et al. 2020.

Figure 1: Finalised monitoring well (in the foreground) and one under drilling in the background
Source: Faitli–Magyar 2018: 5.

Analysis of environmental pollutants produced during fire development

One of the main goals during the intervention at solid waste landfill fires is to minimise the environmental pollution impact on the surrounding environment of the site. Air pollutants include dangerous substances and compounds that are harmful to health and the living and non-living environment. From the point of view of firefighters and site workers, the most consequential impacts are dangerous substances and compounds harmful to human health. During combustion, plastics can release a number of pollutants, which enter the environment mainly as decomposition products of plastics fires. We can currently detect their presence and concentration at the event site via mobile chemical monitoring devices. Such a device is, for example, the Disaster Management's Mobile Laboratory.[13] The first responder units according to my experiences do not have devices capable of detecting dangerous chemical substances. There are only devices on the fire engines that are suitable for measuring carbon monoxide.

[13] Cimer et al. 2021.

In addition to the many dangers of waste fires, the presence of health-damaging vapours and gases can also be considered a real risk factor. Due to the often-protracted nature of firefighting interventions, it follows that regularised respiratory protective devices serve the staff for a limited time. In the last cases, it is necessary to take care of continuous replacement of spare air cylinders for the breathing apparatus, which can pose a serious logistical challenge due to the lack of a breathing base vehicle installed on site. In my opinion, it is necessary to provide combined filters that are suitable for protection against toxic dangerous substances that occur on site. It is recommended to use tools that have a low weight and can be used for a long time, up to 1–2 hours, depending on the degree of contamination. Currently, the effective use time of the breathing apparatus is 30 to 45 minutes, depending on the physical load. Beyond that, due to their considerable weight, they are less suitable for working on marshy ground or on the sides of the landfill.

From the point of view of the environmental impact, another important question to be solved is the treatment of leachate. During the construction of landfills, significant care must be taken to retain, pump out and clean the leachate, which is achieved by laying various geotextiles. The barrier layer of geotextile or foils prevents runoff of and waste-contaminated extinguishing water flowing into the soil or underground water.

However, in case of landfill sites that have not yet been filled up, a common problem is that the fires that occur in the peripheral areas can damage and destroy the foils over a large area. In addition, another challenge is the common practice of operators of landfill sites, that the foils are fixed with used car tires. Vehicle tires can transfer considerable heat and are extremely difficult to extinguish.[14] The toxic combustion products produced in tire fires are also an important source of danger for the responders.[15] In my opinion, it is necessary to enforce the regulation determined by KvVM Decree 20/2006 (IV.5.) on the landfill and certain rules and conditions related to the landfill,[16] which prohibits the dumping of vehicle tires in the area of waste disposal sites.

The procedure currently used to investigate the rupture of the foils includes the assessment of the groundwater of the monitoring wells drilled around the landfills.[17] In my view, the same method can be applied to illegal landfill sites as well.

Conclusions

Based on my research work, it can be concluded that municipal solid waste storages have many sources of environmental hazards. Damage events related to residential waste are significantly part of the long-term interventions, the economic effects of which have not yet been investigated in Hungary. In addition, the currently used firefighting tactics do not define a separate methodology for fires involving landfill

[14] Stefanov et al. 2013: 905.
[15] Sallay 2003: 30.
[16] 20/2006 (IV.5.) KvVM decree on the landfill and certain rules and conditions related to the landfill, 5 § d).
[17] Madon et al. 2019.

waste. Thus, in professional practice, firefighters use standard procedures, which predominantly involve static extinguishing. In these cases, the interventionists try to cover as large an area as possible from one point, with continuous provision of fire water. As a result, the time of the intervention becomes longer and the firewater consumption becomes much larger. This condition could be improved by the combined use of water mist lance device. I also consider it justified to examine the implementation of a mechanised version of the latter firefighting procedure.

Several methods should be considered to prevent and detect the spread of underground fires. When monitoring wells are used, the level of the gas concentration is measured, the indication value of which can be the signal limit value typical for ignition. When the alarm level of the gas concentration is reached, the intervention of the fire brigade is initiated.

Health risks can also be significant during interventions in the landfill areas. Particular attention must therefore be paid to protecting the primary responding firefighters and the population living in the environment from health-damaging effects in events of propagation of toxic combustion products. Environmental pollutants can also have a direct effect on the health of the workers at the landfill site. It is absolutely necessary to ensure the use of appropriate self-protective equipment.

The problems outlined in this article have not yet been fully answered by landfill operators and authorities. It can be concluded that several development opportunities have been identified in the area of landfill safety, in connection with which further research directions have been determined.

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