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Statistical Analysis of Outdoor Waste Fires in Hungary

In Hungary, an average of 1,700 outdoor waste-related fires occur annually. The aim of the present study is to examine these fires at national level and draw the appropriate conclusions. The authors of this study seek to answer the question of what trends can be identified regarding the spatial and temporal distribution of fires. Whether recurring factors can be identified and possible ways to reduce them. How many illegal waste dumps are there in the country and what are the causes? The annual number of fires in landfill sites and the landfills most affected by outdoor fires will also be identified. Analytical work is presented through statistical figures, charts and GIS models.

Keywords: *waste fire, landfill, open-air fire, statistics, GIS data*

Introduction

The basic task of the fire services is to save human life and property from fire and natural disasters. The specialty of waste fires is that, in the event of their occurrence, there is no saving in value. Apart from the fact that no material damage is caused, air and groundwater pollution is significant. The spread of fires must also be taken into account, which can cause further damage. During waste fires, preventing the spread of fire is our primary goal, and reducing the emission of environmentally harmful components is the secondary.

In this article, the authors seek to answer the question of how much of a burden outdoor waste fires place on the national emergency response system. The authors examine the annual and monthly national breakdown of the number of cases, as well as their development trends in a five-year cycle. The frequency of fire incidents is also examined in order for the right conclusions to be drawn. The authors also analyse fires that occur in landfills and look for correlations.

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During the research on waste fires in Hungary, the authors realised that the present study fills a gap, as no comprehensive scientific analysis has yet been made in Hungary regarding the figures, frequency and triggering circumstances of fires related to open-air waste. With this present work the authors aim to fill this gap, during which they hope that the issues of this field will receive more attention soon. Accurate data are of great interest in this area. This is proven by an article published in 2023 by the news portal named *Átlátszó,* which used a superficial method to collect data on the subject.[4] The article also raises an important question about a fire incident at the landfill in Jánossomorja settlement. There have been several fires in the landfill in question and the root causes are also answered in our study.

The timeliness of the topic is well represented by the wildfire in California on 24 July 2024,[5] the 6th largest fire in the state's history. The fire was caused by arson, in which the arsonist tried to get rid of his car wreck by pushing the burning wreck into a ravine.[6] In the Hungarian context, there are also examples of outdoor waste incidents of outstanding importance. The only case in the capital this year with the highest alert level was also related to outdoor waste fire. In the area of railway station "Rákosrendező", in April 2024, disused railway sleepers (accumulated as waste) were burnt.[7] As a result of the investigative work carried out by the authorities, the suspicion of intent was also proven.[8] This clearly shows the timely character of the topic. The resulting data can serve as a basis for future preventive work.

Literature review

The authors have incorporated the conclusions and methods of the following relevant literature to evaluate their own data and to examine the emerging useful correlations.

The prevention of environmental damage associated with the direct pollution of surface and underground waters in relation to landfills is primarily an issue of environmental safety.[9]

Ibrahim et al. in their study entitled "Fires Due to Selfignition in (MSWS) Municipal Solid Waste Storages" describe the hazards of self ignition of stored materials. The composition and presence of substances susceptible to self ignition are also investigated in depth, with a particular focus on solid waste repositories. David Fisher in his online seminar called "Ambient Monitoring of Methane and Management of Fires in Landfills", provide an insight into the practical experience of fires in landfills in California, USA. The presentation provides insight into the primary technological elements of landfill operation that, if not addressed, could potentially lead to fire hazards.

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4 Fülöp 2023.
5 The Department of Forestry and Fire Protection 2024.
6 Dózsa 2024.
7 NDGDM 2024.
8 Bányai 2024.
9 Földi–Padányi 2021.

Péter Debreceni's paper on the investigation and classification of the causes of Hungarian vegetation fires examines the number of forest and vegetation fires and their causes between 2011 and 2020 using statistical methods. His work shows how much of the causes are due to human negligence and other factors. Also, the study prepared by Péter Debreceni and Péter Pántya entitled "Possibilities for Identifying Periods of High Fire Risk" gives an idea of the temporal distribution of vegetation fires and the impact of meteorological factors. The work provides answers to the correlation between precipitation and temperature factors and vegetation fires. In his paper "Analysis of the Environmental Impact of Vegetation Fires from an Environmental Safety Perspective", Zsolt Nagy analyses the comparison of environmental and intervention aspects during wildfires. This includes the interaction between the effectiveness of the intervention and the environmental aspects. Imre Antal and Rudolf Nagy's paper "Fire Safety Assessment of Municipal Waste Management" provides an insight into the major occupational accident and fire safety issues in landfill operations. The causes of the fire are investigated, and a risk-based matrix is established.

Methodology

The initial data sets were provided by the National Directorate General for Disaster Management of the Ministry of the Interior (hereinafter: NDGDM) and the competent departments of the Ministry of Energy (MoE). On behalf of the NDGDM, the authors requested and received access to the records of the Disaster Management Information Program (DMIP) through a research permit. The alerts received by the central emergency services are recorded in the DMIP on an alert sheet, and the details of the incident are also recorded in the same application after the incident. The data requested covers the five-year period from 2019 to 2023, during which the outdoor waste ignited. In the data the authors received from the MoE, the authors were able to see Hungary's annual waste generation and the rates at which it is treated. Using GPS coordinates, the authors were able to depict operating landfills and fires in individual layers on an annual basis. By comparing the two layers, the number of fires in landfills per year could be obtained. Monthly average temperature and precipitation sum data were collected from the HungaroMet web platform.

For the analysis of each question, the calculation of the overall statistical average and minimum–maximum values were used. On graphs, trend analysis of a large number of records was made possible. By creating GIS models, they were able to detect regional distributions and characteristic patterns.

Evaluation of Hungary's waste production

There are three methods used to manage municipal waste:

- recycling or reuse, e.g. through deposit products
- energy recovery, i.e. conversion into heat and electricity in incinerators
- landfilling, i.e. dumping in designated landfill sites

The elements of a complex system that brings together these processes are also called "waste pyramid". In Hungary, an average of 4 million tonnes of municipal waste is generated annually (averaged over the years 2019–2023 and rounded up to a whole number). Table 1 shows the amount of municipal waste generated in Hungary and their recovery rates between the period of 2017–2021.

Table 1: Municipal waste generation and recovery rates between 2017 and 2021 in Hungary

Expressed in tonnes	2017	2018	2019	2020	2021
Utilised in material	1,319,370	1,393,808	1,357,840	1,257,020	1,410,808
Energy recovery	607,633	501,289	514,545	466,117	499,661
Deposit	1,824,811	1,850,627	1,918,634	2,123,738	2,061,269
Total waste generated	**3,767,876**	**3,745,724**	**3,791,000**	**3,930,999**	**4,041,542**

Source: Prepared by Benjámin Hózer based on the data of the MoE, Department of Waste Disposal

In accordance with the European Union's "Circular Economy" plan,[10] Member States have been set a target to reduce the proportion of waste going to landfill to below 10% by 2035. For Hungary, as a Member State eligible for a derogation, this target must be met by 2040. The percentage of waste treated by each treatment method (as a percentage of total waste treated) in recent years is shown in Table 2.

Table 2: Percentage of waste treated by each treatment method in Hungary between 2017 and 2021

Expressed in percentage	2017	2018	2019	2020	2021
Utilised in material	35.5%	37.2%	35.8%	34.0%	36.6%
Energy recovery	16.1%	13.4%	13.6%	12.0%	12.4%
Deposit	48.4%	49.4%	50.6%	54.0%	51.0%

Source: Based on the data of the MOE, Department of Waste Disposal

Table 2 shows that the proportion of waste going to landfill has stagnated at 1–2% in Hungary, based on the latest known data, and accounts for half of all treatment. It can be concluded from this that the amount of landfilled waste should be reduced to one fifth by 2040. Using a linear trend, the proportion of waste going to landfill would have to be reduced by more than 4% each year to meet the target. This would mean nearly 170,000 tonnes less waste landfilled per year. The stagnating trend suggests that landfills will be with us for a long time to come. Significant changes are still needed in the way industry and consumers prefer other waste management methods.

[10] European Commission 2024.

Analysis of data on outdoor waste fires and impact of weather conditions on these fires

In the data stored in the DMIP system, there is a separate checkbox for outdoor waste incidents. The DMIP form is filled in by the officer in charge or the duty commander after the incident. When filling in the form, he ticks the box if the incident involved outdoor waste. However, more information on the nature of the incident can only be obtained if it is accompanied by a text description. Based on a summary of the textual descriptions, the most typical occurrence conditions may be the following:

- fire in a landfill site
- fire at a waste processing site
- fire involving accumulated household waste (on residential property)
- fire in an illegal waste dump
- fire involving accumulated waste at an industrial site
- fire involving waste associated with agricultural works and vegetation fire

Annual outdoor waste incidents in Hungary are illustrated in Figure 1.

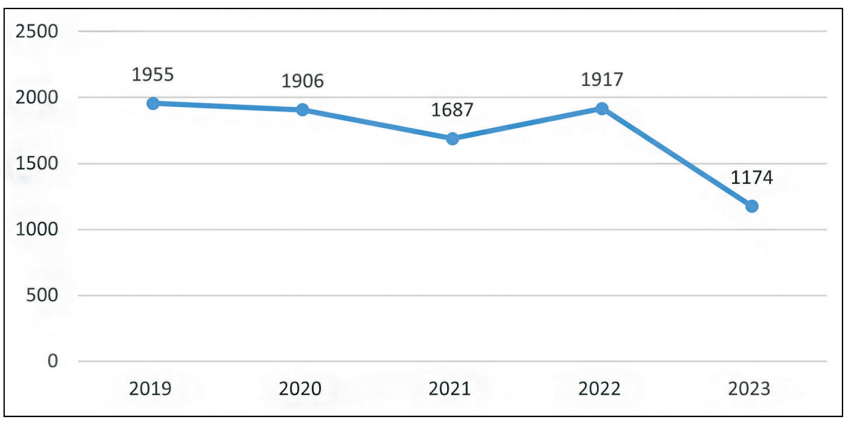

Figure 1: Total number of outdoor waste incidents in Hungary between 2019 and 2023 (total)
Source: compiled by Benjámin Hózer based on NDGDM data

Péter Debreceni analyses the vegetation fires in Hungary with a similar methodology in his above mentioned paper.[11] In his article, a similar correlation is observed when analysing vegetation fire data between 2011 and 2020. The significant reduction in the number of cases in 2023 does not represent a trend reduction, but only a periodic extreme. An overlap between the two statistics is visible in the years 2019 and 2020. Both years show a slight decrease as shown in Figure 2.

[11] Debreceni 2021.

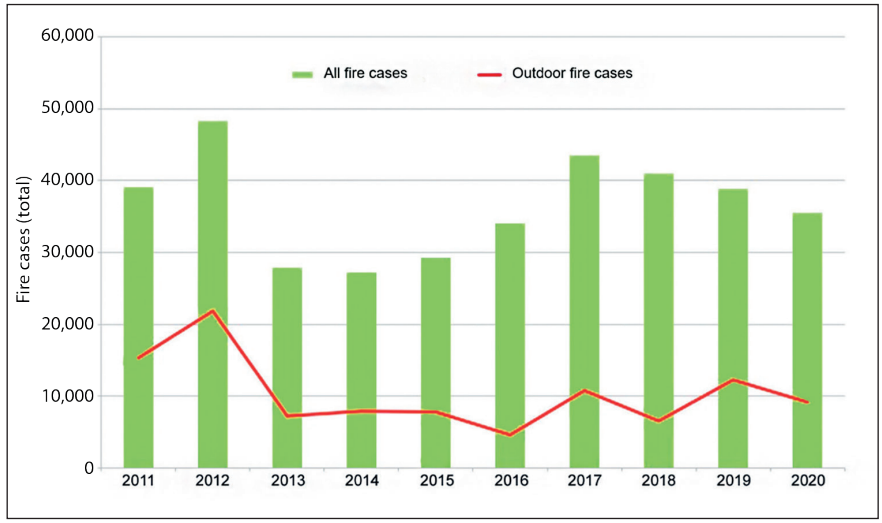

Figure 2: Total vegetation fires and the number of fires in open areas between 2011 and 2020
Source: Debreceni 2021

By analysing the two graphs, a trend can be observed between the number of vegetation fires and the number of fires related to outdoor waste. It can be concluded that, in the circumstances in which they occur, the highest number of outdoor waste-related fires occurs in parallel with vegetation fires.

After examining the circumstances that caused outdoor waste fires, it is also worth looking at the time of their occurrence. Looking at the data for the five years 2019–2023, the following picture emerges in Figure 3.

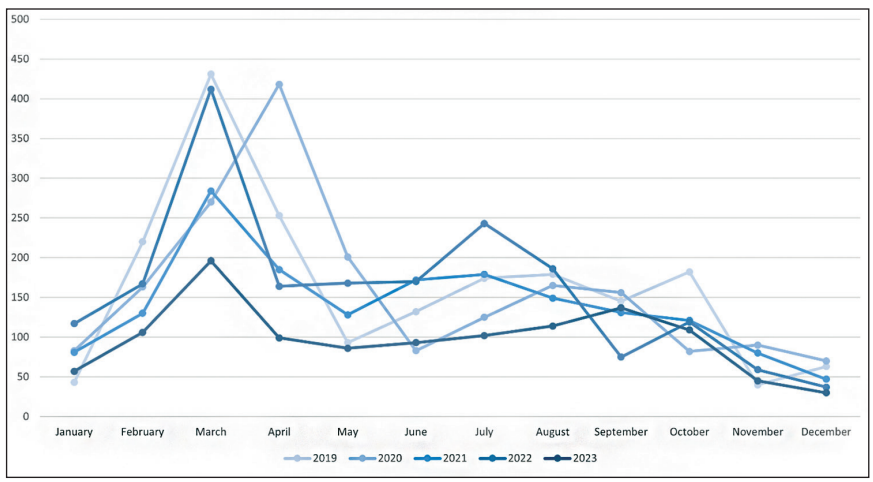

Figure 3: Outdoor waste-related fires between 2019 and 2023, broken down by month (total)
Source: compiled by Benjámin Hózer based on NDGDM data

High values are observed at the beginning of the agricultural season, i.e. in March and, except in one year, in April. The following period shows a stagnating trend until the arrival of the wet weather in October. With the onset of cold weather, the incidence rate drops significantly.

In addition to agricultural work, it is also worth observing the weather aspects. Figure 4 compares the outdoor waste fires that occurred in 2019, broken down by month, with the average monthly average temperature and precipitation totals.

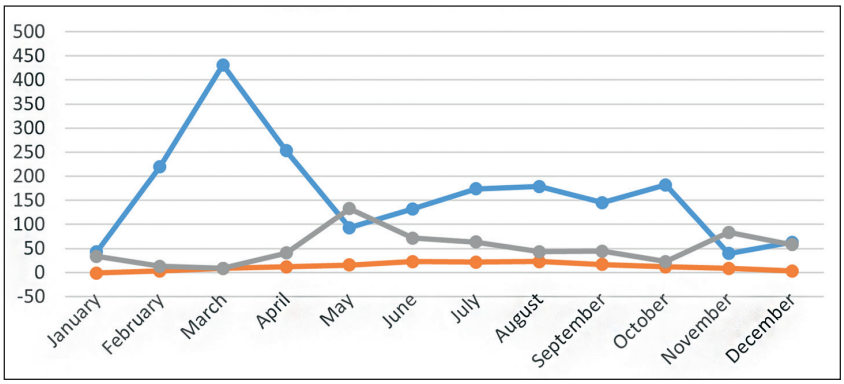

Figure 4: Comparison of outdoor waste-related fires with average heat and rainfall values for 2019
Source: compiled by Benjámin Hózer based on NDGDM and HungaroMet data

Figure 4 shows that as rainfall decreases, the number of damage events increases. The months of March and October are outstanding examples. May and November, on the other hand, are the months with the highest rainfall, so the number of fires remains lower. A similar correlation can be observed if we compare the data with one of the graphs in the work of Debreceni–Pántya 2019 in Figure 5.

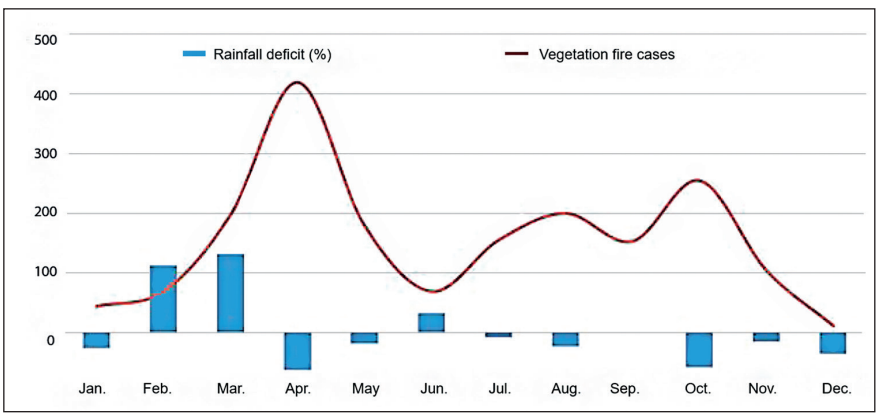

Figure 5: National monthly precipitation totals expressed as a percentage of the multi-year (1981–2010) average and comparison of vegetation fire occurrence rates in 2018
Source: Debreceni– Pántya 2019

By comparing Figures 4 and 5, a clear parallel can be drawn between outdoor waste-related fires and vegetation fires. Between 2018 and 2019, the trend has not changed significantly and there is a clear correlation between higher fire occurrences due to low precipitation and high temperatures.

Waste fires caused by human activity

In addition to weather factors and the triggering effect of agricultural work, other causes should also be considered.

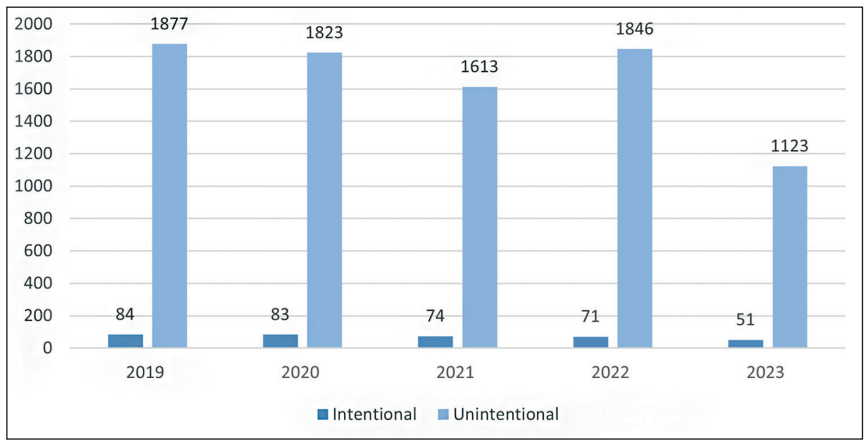

Figure 6: Presumed intentional and unintentional outdoor fires related to outdoor waste between 2019 and 2023
Source: compiled by Benjámin Hózer based on NDGDM data

Looking at the average of the 5 years examined in Figure 6, we can see that 4.5% of the fires that occurred were suspected to be intentional. The exception to this is the year 2022, where the average is only 3.8%. Taking the national data into account, the authors cannot identify any trends, the values are stagnating. The authors presented the GIS data as a case study.

Using the GIS model, no recurrent trend can be seen at national level either, however, local hotspots can be identified. The latter are typically observed near large cities and in presumably illegal waste dumps located slightly away from populated areas. One prominent example is Gyár Street in the municipality of Kerepes, Pest County. In the area under investigation, the issue of waste collected and burnt by local residents has been unresolved for many years. The large number of incidents over five years has resulted in the street being clearly delineated by GPS coordinates of the incidents in Figure 7.

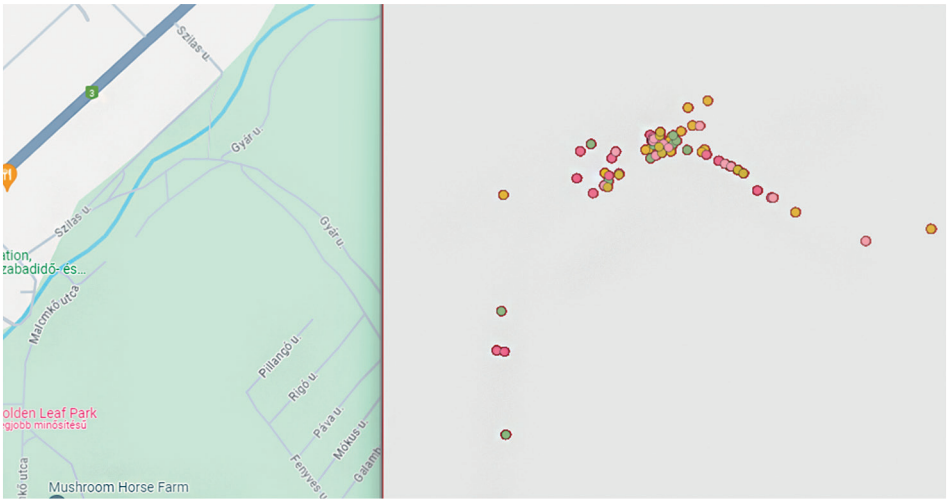

Figure 7: Fires from illegal waste dumps in Gyár Street, Kerepes, between 2019 and 2023
Source: compiled by Benjámin Hózer based on Google Maps and NDGDM data

The low number of allegedly deliberate fires and the lack of national trends suggest that the prevention and management of similar offences and crimes should be undertaken at local level. A good example of this can also be seen in the mentioned area of Kerepes settlement, where a comprehensive waste disposal programme was launched last year under the leadership of the mayor.[12]

The scope of the creation and prevention of landfill fires is closely related to the issues of the available public utility systems, such as the resilience of firefighting water systems,[13] or the effective operation of the drainage of leachate. An additional safety organisation task of landfill safety is also the prescription of operator occupational health and safety obligations related to chemical hazards.[14]

Evaluation of the experience of the 'Hulladékradar' application

In April 2020, the so-called 'Hulladékradar' [Waste radar] application was launched by the Government Information Technology Development Agency, under the professional supervision of the Ministry of Energy (MoE). The app aims to provide a platform for the public to report illegal waste dumping to the authorities. The request for data from the Ministry of Energy has made it possible to view the figures of the reports on a national level, broken down by month.

[12] 24.hu 2024.
[13] Kovács–Dénes 2019.
[14] Nagy 2023.

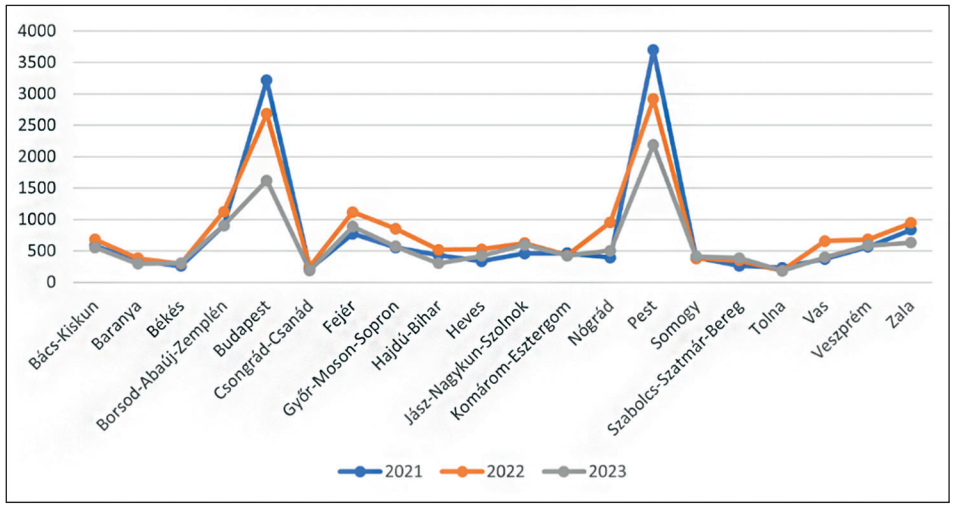

Figure 8: Notifications of illegal waste dumps between 2021 and 2023, broken down by county (number)
Source: compiled by Benjámin Hózer based on MOE data

Figure 8 shows that the capital and its agglomeration Pest County are the most affected territory by illegal dumping. Data for 2020 has not been included as it would have been a truncated year and would have distorted the graph. The correlation between outdoor waste fires and illegal dumping can be contrasted with Figure 9.

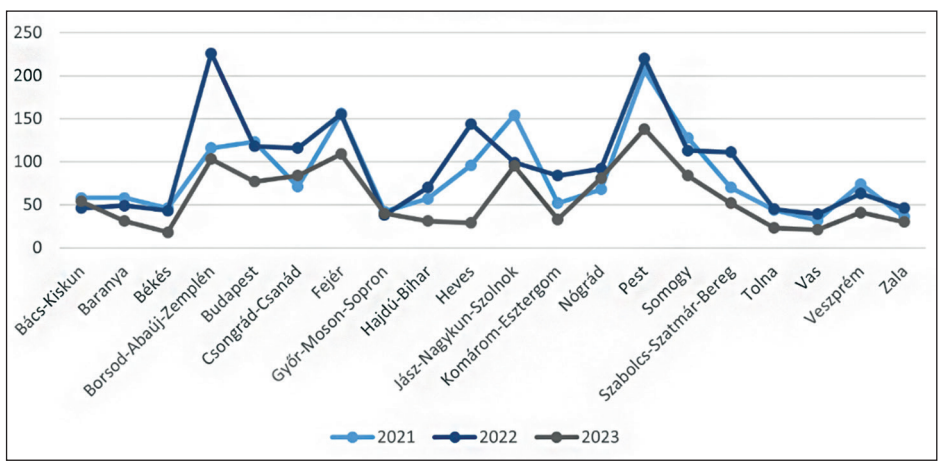

Figure 9: Outdoor waste-related fires by county between 2021 and 2023
Source: compiled by Benjámin Hózer based on NDGDM data

Comparing Figures 8 and 9, we can see that the trends in illegal waste landfill are significantly correlated with fires related to outdoor waste. The Pest and Borsod-Abaúj-Zemplén counties show exceptionally high values. This suggests that a significant proportion of outdoor waste fires are related to weather factors (dry weather, higher number of incidents) and the number of illegal waste dumps. Figure 10 shows the data on the number of notifications and fires in the year 2023.

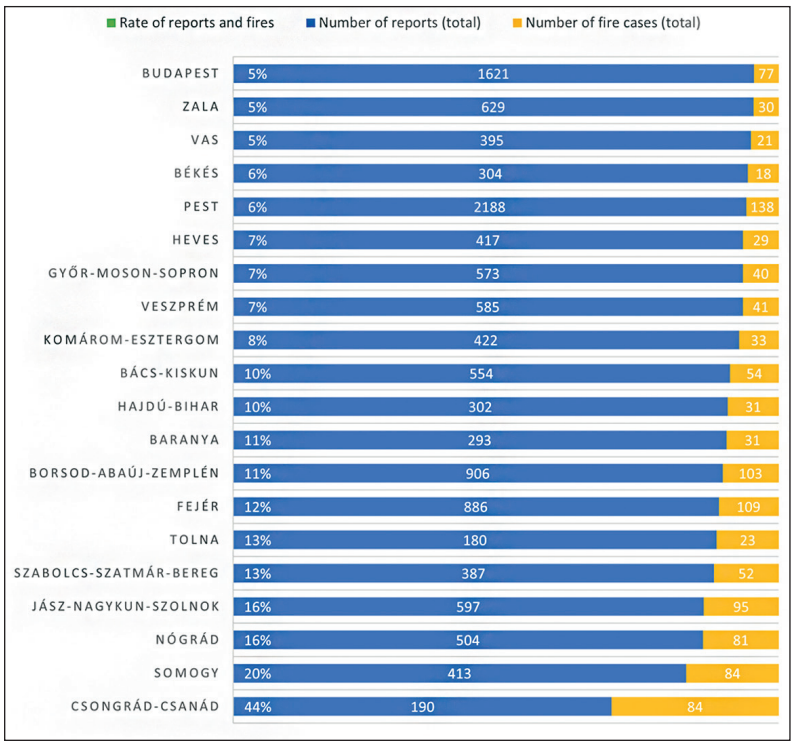

Figure 10: Number of reports of illegal waste dumps and number of open-air waste-related fires and their relative proportions in 2023

Source: compiled by Benjámin Hózer based on NDGDM and MOE data

Figure 10 shows that Csongrád-Csanád County has the worst indicator, with 190 notifications and 84 fires, which implies a 44% rate. However, this does not mean that all 84 fires involved illegal dumping. The capital city has the best rate, although the second highest number of reports comes from here, after Pest County. A GIS model can be used to view the most seriously affected fires in the capital and its agglomeration areas.

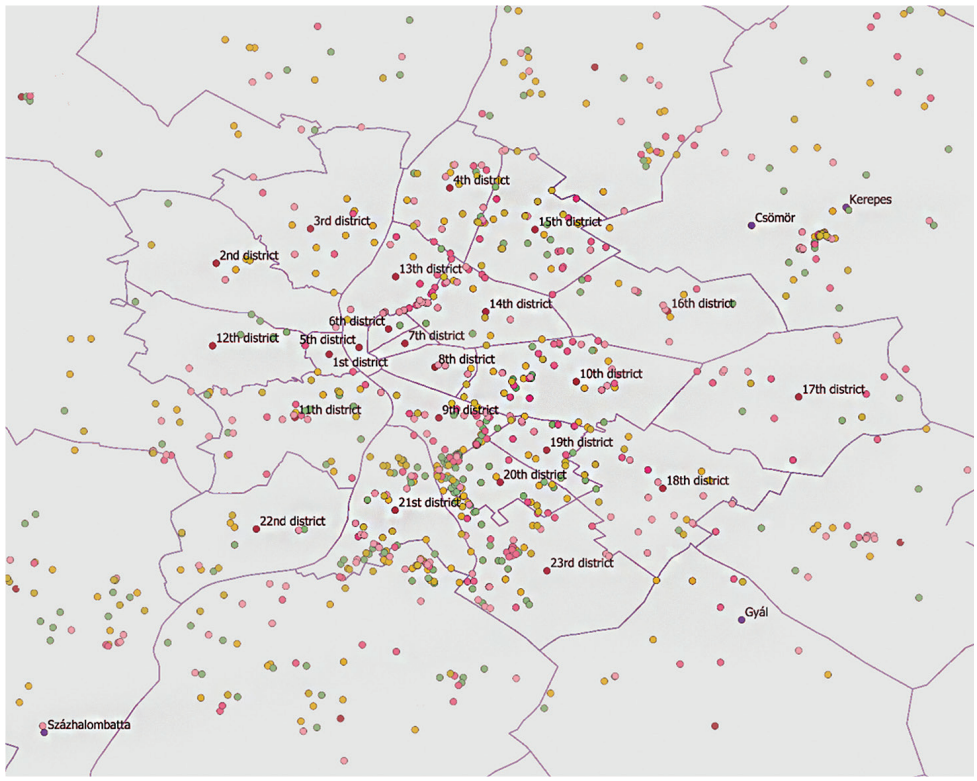

Figure 11: Open-air waste-related fires in the capital and its surrounding area between 2019 and 2023
Source: compiled by Benjámin Hózer based on NDGDM data

The GIS model in Figure 11 visually shows that the most affected segment in the capital is the forested area between the cities of Csepel and Pesterzsébet, next to Ráckeve's bank of the Danube, and the neighbouring forest on Határ road, where the homeless problem is significant. Similar densities and triggers can be observed in the railway station 'Rákosrendező' area between districts XIII and XIV.

When examining the national GIS model, the following picture emerges:

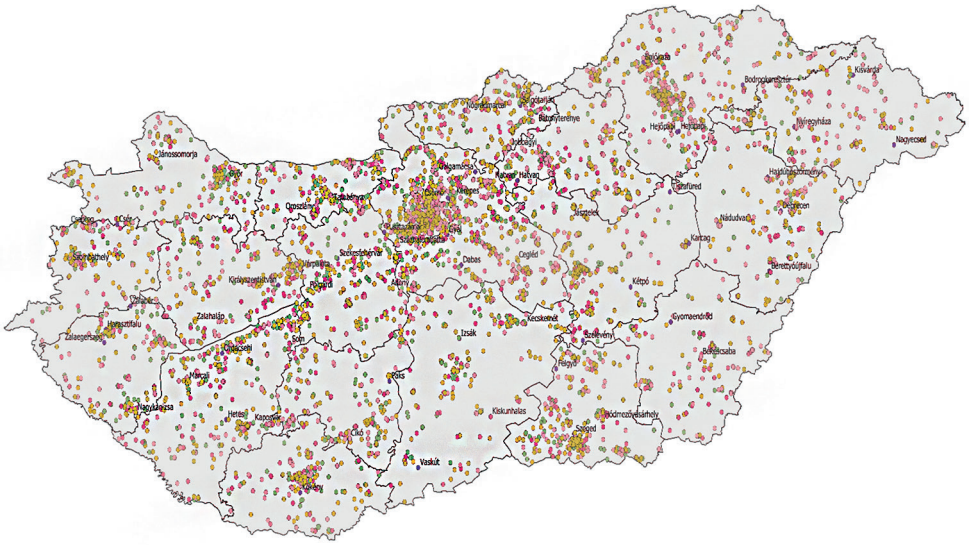

Figure 12: Hungary's outdoor waste-related fires and operating landfills between 2019–2023
Source: compiled by Benjámin Hózer based on NDGDM and MOE data

A densification is observed in Figure 12 in large cities and county centres. A similar phenomenon can be found in areas more heavily affected by tourism but less densely populated on a permanent basis, such as the southern shore of Lake Balaton. Also, an outlier belt can be observed in the Miskolc area closed by the landfills between the settlements of Sajókaza and Hejőpapi.

As stated earlier, trends in illegal waste generation need to be addressed at local level. A comprehensive country-wide methodology is currently not known, but trends and root causes can be identified. Experience has shown that citizens often resort to arson in relation to illegal waste landfills when they find the action of the authorities in this respect unsatisfactory. Moreover, the burning of garden waste instead of composting is still an integral part of the Hungarian public spirit, which also increases the number of similar incidents, which can also escalate into vegetation fires.

A good example of illegal waste management is the activity of the 'Magyar Közút'. Their 80 operating sites, with 4,000 employees, collect 10–12 million kilograms of discarded waste per year.[15] In cases where the triggering factor for outdoor fires is known, human irresponsibility is the most important factor. Examples include discarded cigarette butts. This makes the work of the road safety staff a priority in the field of prevention.

[15] Pintér 2024.

Assessment of higher-alert outdoor waste fires

Between 2019 and 2023, there were a total of 20 outdoor waste incidents with an alert level higher than the lowest "one" (I). Figure 13 illustrates the distribution of these incidents according to the circumstances of occurrence.

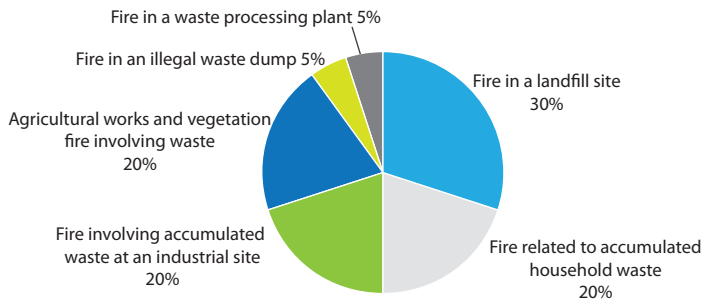

Figure 13: Location of outdoor waste fires of alert levels II–V between 2019 and 2023
Source: compiled by Benjámin Hózer based on NDGDM data

As seen in Figure 13, the vast majority of outdoor waste incidents (99.99%) end with a level I alert. As previously stated, the circumstances of their occurrence are typically fires associated with vegetation fires or illegal dumping of waste. However, the higher alarm levels, i.e. prolonged damage events, show a different trend. The proportion of fires involving large areas of agricultural work and fires caused by irresponsibly treated waste in industrial plants remains significant. However, fires in landfill sites represent an even larger proportion. It is therefore worth examining how many fires occur in landfills in Hungary each year.

The DMIP data sheets do not indicate whether the fire occurred in a landfill site, but at most the text description would give an indication. However, this cannot be reasonably filtered out from nearly 2,000 data sheets per year, and no query can be made on this criterion. For this reason, modelling was carried out using a GIS model, superimposing the coordinates of known landfills and the coordinates of fires. By extracting the fire markers within 300 m of the landfill sites, the authors were able to perform an aggregation, which yielded the following values in Table 3.

Table 3: Number of fires in landfill sites peryear (total)

Year	2019	2020	2021	2022	2023	∑
Number of fire cases	24	23	29	33	27	136

Source: compiled by Benjámin Hózer based on NDGDM data

The majority of the 33 landfills surveyed had an average of 1–3 fires between 2019–2023. However, six of these landfills show outliers as seen in Table 4.

Table 4: Total number of landfills with high number of fires between 2019 and 2023 (total)

Location	Number of fire cases
Marcali	19
Oroszlány	19
Jánossomorja	17
Jobbágyi	10
Nádudvar	9
Zalahaláp	7

Source: compiled by Benjámin Hózer based on NDGDM data

Among the priority landfills, the authors had the opportunity to inspect the landfill at the settlement of Jánossomorja. After consultation with a representative of the local volunteer fire brigade association of Jánossomorja city, it was established that the higher number of incidents at the site is typically due to the frequent failure to carry out the technologically required landfill gas extraction due to technical failure. The monitoring of the enforcement of the technological standards is the responsibility of the Government Offices. It is clear, however, that the collateral consequences can now extend to several disciplines. As demonstrated in our previous publications, most fires in landfills are due to the failure of a technological step.

One of the important means of preventing fires that may occur in industrial sites like waste collection installations and landfills is the establishment and operation of fire monitoring and alarm systems,[16] which fulfil their purpose together with fire extinguishing systems.[17] Property protection systems are also part of the site physical protection system. As a result of technological development, camera systems installed for the purpose of property and occupational safety tasks have also come to the fore.[18] Further research can be conducted on the examination of issues related to the application of artificial intelligence tools.[19]

Conclusions

The following conclusions were drawn from the figures, diagrams and GIS models:

It has been found that 99.99% of outdoor waste fires end with a level I alert. The majority of outdoor waste incidents were associated with vegetation fires. This is confirmed by a close correlation with the occurrence curves and frequency of vegetation fires, which has been confirmed by other studies in the same time periods. A further parallel can be observed in the spike in the number of fires in the months of March and April, i.e. the time when agricultural work starts. Another important influencing factor is the burning of garden waste, which can easily turn into a large-scale fire.

Weather factors have a significant influence on the occurrence of outdoor waste-related fires. Rising average temperature factors increase the number of incidents, while cool periods reduce them. Increasing periods of rainfall also reduce the number of incidents.

[16] Érces et al. 2023a.
[17] Érces et al. 2023b.
[18] Tóth 2023.
[19] Tóth 2024.

There is no consistent pattern in the number of fires in illegal waste dumps. The causes of such fires need to be investigated at local level. At local level, however, patterns can be detected in some areas, based on GIS models. The areas most affected by illegal dumping are the capital and Pest County, especially those areas where more people live on the periphery of society.

The initial circumstances of outdoor waste fires reaching a higher alert level can be attributed to five factors. Prominent among these is damage to landfill sites. On an annual basis, the authors have been able to locate between 20 and 30 fires in landfill sites on the basis of the GIS data available. The majority of landfills have between 1 and 3 fires per year. Of these, six have a significantly higher number of fires. In consultation with other colleagues, it has been established that the higher number of incidents is due to non-compliance with technological standards. Examples include the failure to carry out daily covering and to extract depot gas.

The high number of outdoor waste incidents places a very heavy burden on the disaster management organisation. The figures clearly show that the two hotspots are the escalation of vegetation fires and fires deliberately caused by illegal waste dumps. The National Fire Prevention Commission is paying great attention to the containment of forest and vegetation fires. However, the eradication of illegal waste dumps is a regulation that affects many areas. In case of private land, the first step is for the competent local authority to contact the owner of the land and ask him to clean up the dump. However, the owner is almost 100% innocent in almost all cases. If the owner fails to come forward, only then will the municipality have the landfill removed ex officio. The resulting long delays are often not appreciated by residents in the area, who prefer to set the dump on fire to raise awareness. It would be preferable to set up a central competent body to eliminate these dumps, as this would speed up the process of enforcing fire and environmental protection.

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