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FIRES IN THE WASTE MANAGEMENT SECTOR IN ROMANIA. FREQUENCY, CAUSES AND SPATIAL DISTRIBUTION

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ABSTRACT. – Fires in the Waste Management Sector in Romania. Frequency, Causes and Spatial Distribution. Large waste fires are severe hazards to the human health and to the environment due to the sudden release of pollutants they imply. In this study we take a first step towards a better understanding of this phenomenon in Romania by creating and analyzing a waste fire database. Starting from a public data set regarding firefighting interventions in the waste management sector between 2016 and 2020, we have identified three main types of fires – fires at the municipal waste collection points, surface waste fires and fires at waste recycling facilities. We further calculated the frequency of these fires, identified their causes, and their spatial distribution.

Keywords: *waste fires, health, hazard, persistent organic pollutants, fire causes.*

1. INTRODUCTION

The waste management sector has to deal with several types of environmental challenges on a daily basis (e.g., landfill gas emissions, soil contamination, pollution of groundwater by landfill leachate, etc.); in addition, inadvertent events, such as fires, often require interventions. Large waste fires suddenly release big quantities of greenhouse gases and pollutants and represent severe hazards for the environment and human health. Bihałowicz *et al* (2021) estimated that for 79 large waste fires occurring in 2018 in Poland the emission of PM_{10} represented more than 2% of the national emissions, being almost equal to the emissions of the entire transport sector in the Warsaw agglomeration in a year. Moreover, the authors calculated that waste fires emitted the same amount of CO_2 that would have been released during 75 years of waste storage in landfills.

Alongside these substantial but rather infrequent events, there is the widespread practice of burning waste on a regular basis, as a means of waste disposal, especially in developing countries, contributing to a slow and insidious

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environmental pollution (Ferronato and Torretta, 2019; IPEN, 2021). However, the backyard burning of waste and setting dumpsites on fire, while less frequent, is still present in the US and EU as well (Muñoz and Panero, 2006; Mihai *et al*, 2019; Buzzo *et al*, 2021), requiring burning bans and other measures in order to curb these practices (e.g., EC, 2009; WDHS, 2015).

The fires release pollutants already present in the burning materials, while, at the same time contributing to the emission of new ones: polycyclic aromatic hydrocarbons (PAHs), dioxins, and furans, among others. PAHs result from burning carbon-containing compounds; dioxins and furans result from the combustion of carbon-containing materials in the presence of chlorine or other halogens. They are persistent organic pollutants (POPs) that are able to bind to the fat cells in the animal and human body and tend to persist into the environment and into the animal tissues for long periods (Tuomisto, 2019). Many combustion processes release various quantities of those chemicals, but in the cases of open burning of waste and accidental waste fires, the rather low temperature of the fire, the poor ventilation/low oxygen supply and the high diversity of materials that serve as fuel represent the main factors that contribute to a higher release of pollutants than it would result in the process of controlled combustion (e.g., in regulated industrial processes and proper waste incinerators). Estimated emissions show that the open burning of one kilogram of waste may cause the same amount of dioxin emission as ten tons of waste burned in a modern waste incinerator (EC, 2009).

While dioxin reducing measures imposed to the industry in Europe and US greatly contributed to decreasing the environmental pollution in the last forty years (Tuomisto, 2019; BMU, 2021), other unaddressed combustion processes have become the main source of such chemicals. A dioxin inventory for the New York Harbor area estimated that uncontrolled burning (mainly backyard burning, structural fires and fires during solid waste management) was responsible for two thirds of all dioxin emissions into the air, and half the dioxin contained in ash residues (Muñoz and Panero, 2006). In Germany, fires were responsible for 44.5% of all dioxin emissions in 2018 (BMU, 2021), while in Canada, the open burning of residential waste produces more dioxins and dioxin-like chemicals than all the industrial activities combined (Government of Canada, 2015).

Because of the potentially heavy impact waste fires have on the environment and on human health, environmental experts and organizations (e.g., EPA, 2003; Muñoz and Panero, 2006; EC, 2009; WDHS, 2015; IPEN, 2021, etc.) have listed waste fire prevention and banning the domestic waste burning as important measures for reducing pollution with POPs. In the present study we take a snapshot of fires in the waste management sector in Romania. Our objectives are to understand how frequent they are, what are their main causes and what is their spatial distribution.

2. MATERIALS AND METHODS

2.1 Waste fires database

We used data form the Romanian Inspectorate for Emergency Situations (Inspectoratul General pentru Situaţii de Urgenţă/IGSU) in order to create a waste fires database. The dataset received from IGSU listed the interventions carried out by the firefight departments upon fires occurring in the waste management sector during the 2016-2020 period (the date and duration of the intervention, the county in which the intervention took place, the determining circumstance of the fire and a short description of the intervention, that in many cases provided details about the type and quantity of burnt waste and the fire-affected area). In this five-year period, there were 3039 firefighters' interventions upon fires occurring in waste management sector. Comparing this to the yearly average number of interventions upon all fires, this seems like a very small figure (around 30000 interventions/year upon all types of fires and only around 600 interventions/year upon waste fires). Because the dataset contains firefighters' interventions, not fire events, in the case of large fires more interventions were recorded, even if it was still only one fire event (if several fire crews were involved in extinguishing it). Based on intervention dates and descriptions we created a waste fires database by assigning the identified multiple firefighters' interventions to the same fire, to a single fire event. Another database resulted, showing 2707 fires occurring at waste management facilities or involving waste burning between 2016 and 2020.

2.2 Database analysis

Based on the description of the firefighters' interventions, we classified the fires into three main categories: *fires at municipal waste collection points, surface waste fires and fires at waste recycling facilities*. The category referring to fires at municipal waste collection points resulted from descriptions of dumpster, waste bins and recycling containers fires. In many cases, other items were damaged, such as street furniture (benches, streetlights), small constructions enclosing the waste collection points, cars parked nearby, fences, and walls of the buildings located nearby the waste collection points. Surface waste fires refer to open burning of waste on small or large areas such as waste and vegetation fires, dumpsites and landfill fires. Fires at waste recycling facilities usually involve big quantities of recycling waste (paper and cardboard, plastic, textiles, metal waste, hazardous and industrial waste, waste from electrical and electronic equipment/WEEE) deposited in piles, baled, or stored in containers.

Fires occurring at facilities collecting and recycling end-of-life vehicles (scrap yards) are also included in this category. Sometimes halls and other buildings, machineries and vehicles were damaged or have been burned down in this kind of fires.

We further calculated fire frequency by the above-described categories in every county in Romania and identified the cause of each fire (based on the description of the determining circumstance in the firefighters' reports). The main causes were defined as: *intentional burning* (mainly "intentional use of an ignition source to start the fire", but also "intentional or fault creation of fire conditions", "children playing with fire", etc.), *open burning* ("open fire in open areas"), *smoking* (mostly "smoking in restricted areas or in places not properly secured against potential fire"), *self-ignition* (mostly "self-ignition by contact with the air or the oxygen", "self-ignition of mixed-substances", self-ignition as a consequence of poor ventilation, etc., and in several occasions, "accumulated, concentrated or reflected solar heat" or other natural phenomena), *malfunctioning devices or improper use of equipment* (faulty appliances, electrical tools and machineries, inadequate use of such items, sparks, defective electrical cables or electrical installations, etc.), and *other causes* ("hot ashes and ember", "open fire in closed areas", etc. and in cases in which the determining circumstances of the fires were not specified).

3. RESULTS AND DISCUSSION

3.1 Fires at municipal waste collection points

Most of the fires reported in the waste management sector in Romania occurred at municipal waste collection points (2056 fires). The public IGSU dataset does not report the exact location of the firefighter's interventions; however, we assume most of those fires occurred in urban areas, where municipal waste collection is better implemented and where public firefighting departments function to respond to such fire alarms. We can note that many fires occurred in more urbanized areas such as Bucureşti-Ilfov (321 fires), Cluj County (130), Timiş County (107), etc.

The majority of these fires started from "smoking in restricted areas or in places not properly secured against potential fire" (most probably because lit matches and cigarettes were discarded in waste containers). Other frequent causes were intentional burning and open burning (fig. 1).

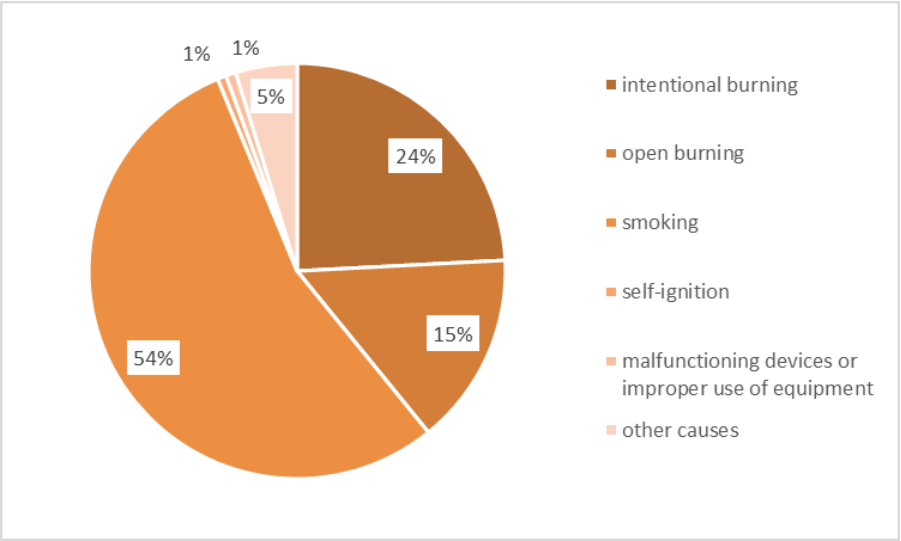

Fig. 1. Main causes of fires at municipal waste collecting points in Romania.
Source: own calculation based on data from IGSU

In terms of environmental impacts, we can compare these fires to open burning of waste in barrels (especially if the waste was collected in metal containers). Several studies reviewed by Costner (2006) have shown that the incomplete combustion of household waste (because of low air flow) in the presence of metals hugely increases the emissions of dioxins and dioxins-like compounds. Also, as many of the waste containers are made of plastic and they burn together with the waste in the fire, this contributes to the releasing of increasing amounts of PM10 and PAHs into the air (Hoffer *et al*, 2020). Moreover, extinguishing fires with water and foam contributes to the local pollution with ashes and chemicals that washes away from the fire site and accumulates in soil and wastewater, and further in groundwater and rivers.

3.2 Surface waste fires

The burned materials in surface waste fires usually are household waste, textile waste, voluminous waste (furniture, used mattresses etc.), used tires, that can often be found in informal dumpsites or abandoned on public space, but also waste and vegetation on large areas, and municipal waste at sanitary landfills. Between 2016 and 2020, 518 such fires happened, averaging 104 fires/year. Most of them occurred in the București-Ilfov area (184 fires), Cluj County (40), Mureș County (38), Suceava County (25), Galați County (26) and Giurgiu County (24). 27 out of the 41 counties in Romania recorded less than 10 surface waste fires in the analyzed period.

Almost half of the surface waste fires were caused by open burning and intentional burning (fig. 2). Since not all the rural communities in Romania are located in areas covered by waste collecting services, the open dumping and open burning of the waste is still a widespread practice (see, for example, Mihai *et al,* 2019); this behavior may explain the high number of fires intentionally started by people. Other 32% of the fires in this category were started non-intentionally, by smoking-related actions, and 14% of them were caused by self-ignition; we assume those were landfills fires. The high content of organic matter in the residual waste in Romania (according to PNGD, biowaste represents more than 50% of the collected municipal waste) contributes to the accumulation of landfill gases (mostly methane), and the combustible materials such as plastic, papers and textiles supply the fire with more fuel. Another explanation for the self-ignition of fires in landfills can be an incomplete extinguishing of a previous fire that reignites (Mikalsen *et al.*, 2021). This latter supposition may be supported by the presence of series of fires at the same landfill in short periods of times (e.g., 10 fires at the Cluj-Napoca landfill in July 2017, 8 fires at the Sighișoara landfill in September 2019).

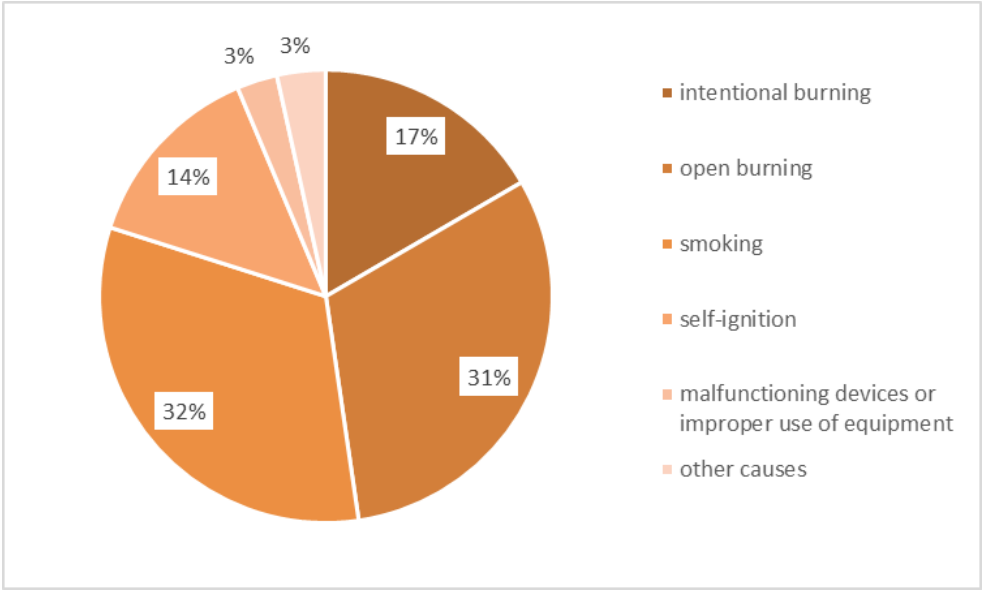

Fig. 2. Main causes of surface waste fires in Romania.
Source: own calculation based on data from IGSU

Out of the 518 surface waste fires, more than a quarter (135 fires) was represented by fires in which waste and vegetation burnt together. In these cases, it is not clear which one was the first, the waste fire or the dry vegetation

fire. However, in the cases in which the firefighters' reports describe areas of tens to hundreds square meters of burnt vegetation, one can assume it was a waste fire that propagated to the vegetation nearby – most of the waste and vegetation fires in the database are in this category (90 fires). However, there were 45 cases in which the fires affected thousands of square meters or even hectares of vegetation. The presence of such large vegetation areas suggests these fires occurred in more rural landscapes and that they were either vegetation fires that also burnt small quantities of waste, either landfill fires, if the amount of burnt waste was estimated in tons.

In several cases, the fire reports listed mostly electrical cables (8 fires) and used tires (25 fires) as burnt materials. The plastic coating of several types of electrical cables is made of PVC (polyvinyl chloride), a type of plastic with a high content of chlorine. With the added metal core of the cables, a harmful combination results, with a very high dioxin and PAHs production potential when burnt (Costner, 2006; Blomqvist *et al*, 2012), that leads to lasting contamination of soil with POPs. We can observe in our database a high spatial concentration of fires in which electrical cables were burnt in the Bucureşti-Ilfov area (seven out of the eight such fires reported, the other one being in the adjacent county, Giurgiu). The media and several NGOs have been documenting these issues for many years now, describing how an informal recycling sector has been growing around Bucharest, contributing to increasing air pollution into the city and to persistent environmental pollution in the nearby rural areas (Ignat, 2013; Ilie, 2021).

The tire fires are also harmful for the environment and human health. A study on a large tire fire in Lithuania has revealed very high quantities of PAHs and other pollutants, released into the air and into the soil, up to 10 km in the surrounding areas, away from the fire site (Raudonytė-Svirbutavičienė *et al*, 2022). However, the tire fires that occurred in the analyzed period in Romania were much smaller than the one described in the cited study – the largest of them involving around 100 used tires each (a fire on the 20th of December 2017 in Mehedinţi County and another one on 3rd of September, 2019 in Mureş County), so one can assume the contamination was moderate and limited to the exact fire site.

3.3 Fires at waste recycling facilities

During the 2016-2020 period, 133 fires occurred at waste recycling facilities. The areas that were most affected by this type of fire were the Bucureşti-Ilfov area (26), Prahova County (11) and Galaţi County (10). The most impactful in terms of environment pollution are large WEEE fires. During the analyzed period, we identified four such fires, the largest one, in Dâmboviţa County involving 15 tons of WEEE. The high content of plastic and metals in

these kinds of waste produces large amounts of POPs when burnt. IPEN (2021) analyzed the dioxin content of the eggs collected from free range chickens living in areas near landfills and dumpsites catching fire frequently (located mostly in Asia and Africa). The eggs collected nearby dumpsites and landfills containing WEEE waste had the highest dioxin content of all the analyzed samples – eating half an egg from such a site would result in exceeding the tolerable dietary intake for dioxins by 12-fold to 149-fold (IPEN, 2021, p. 72).

Fires at facilities collecting and recycling end-of-life vehicles are equally dangerous because of the diverse type of materials involved: metal, rubber, plastic, textile (usually with high content of plastic and fire-retardant treatment) and various hazardous wastes such oils, batteries etc., that make a very pollutant mix when burnt together (McNamee *et al,* 2019). Between 2016 and 2020 there were 35 fires at facilities collecting and recycling end-of-life vehicles. The largest one occurred in the Bucuresti-Ilfov area, on September 1st, 2016 – 300 vehicles burnt in the fire, on a 1000m^2 area and on a height of four meters. Sometimes these kind of waste recycling facilities are located in densely populated areas, in which case, a fire is a direct threat to the safety and health of the population living nearby - it was the case of a scrap yard fire in Bucharest on the 5th of June 2021 that required the evacuation of 70 people (Oprea, 2021).

Fires at facilities collecting hazardous waste are fewer (11 cases in our database). A probable reason is the fact that there are fewer such facilities than those dealing with non-hazardous waste and, as Mikalsen *et al* (2021) found, because better fire prevention measures are implemented at these sites. Based on the frequency of fires in waste facilities in the Scandinavian countries and of the potential economic and environmental consequences of those fires, the cited authors classified waste fractions in terms of fire risk. According to them, the greatest fire risk is associated to residual waste because of the higher frequency of fires on that kind of waste and of the many possible consequences of those fires (usually large quantities of burning waste, damaged equipment and machineries, increased pollutants emission due to the heterogeneous composition of the waste). WEEE was ranked second in terms of fire risk, paper and cardboard third and hazardous waste forth. Despite the possible greater impact on the environment of hazardous waste fires, their low frequency contributes to a lower overall risk.

In Romania, fires at waste recycling facilities are caused mainly by the inappropriate usage of tools, machineries, and appliances, by sparks generated while using cutting and metal welding tools, by faulty or improvised electrical installations, etc. (fig. 3). Another frequent cause is self-ignition (17% of fires) – mostly by creating conditions favourable for a fire by the inappropriate storage of the waste. Also, smoking was responsible for 14% of the fires in this waste management sector.

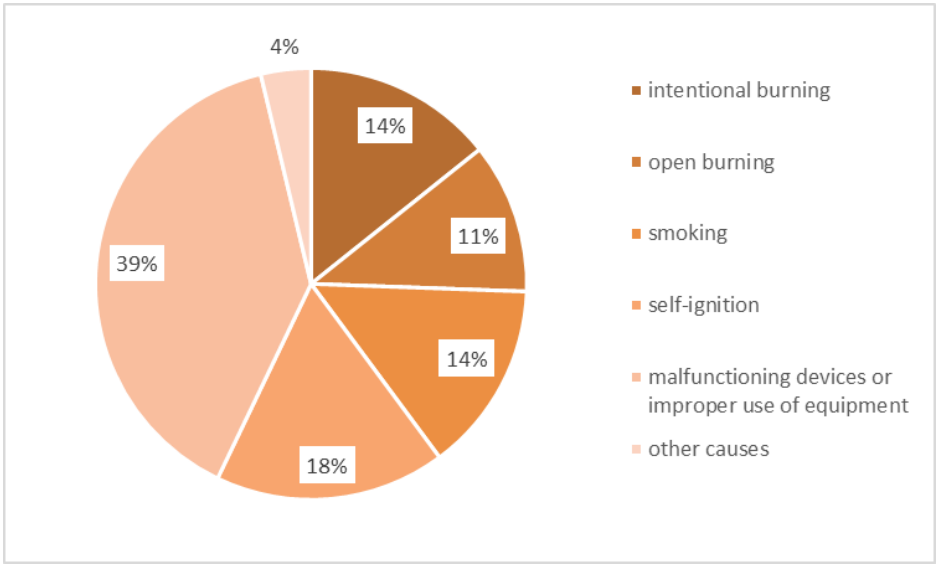

Fig. 3. Main causes of fires at waste recycling facilities in Romania.
Source: own calculation based on data from IGSU

4. CONCLUSIONS

The contribution of the waste management sector to greenhouse gas emission and to environmental pollution has been getting much attention from the scientific community. However, the part that waste fires play in this is not very well known yet. Making estimates is hard because of the accidental manner in which these events happen and because of the unique characteristics of every fire. That is why a database containing fires, such as the one we produced, is a necessary starting point for understanding the magnitude of the phenomenon. Further research is needed in order to assess the impact of waste fires upon the environment and human health in Romania, especially in places where large fires are recurrent events, such as in the Bucureşti-Ilfov area, and in several counties - Cluj, Mureş, Suceava, Giurgiu, Galaţi, Prahova.

While usually small, frequent fires taking place at municipal waste collecting points pollute the air and may affect human health. Preventing them could be an easy way of reducing urban pollution. Since smoking is the leading cause for fires at municipal waste collecting points, public awareness campaigns on the fire risks of smoking may be sensible actions that local authorities could implement.

The open burning of waste is another important cause for waste fires in Romania, especially in rural areas. Enforcing the existing burning bans and awareness campaign could work in this case too in order to decrease the frequency of surface waste fires. However, a functional waste collecting system needs to be put in place first.

Malfunctioning devices or improper use of equipment have been the leading causes for fires in waste recycling facilities in Romania. This suggests that a better fire prevention is needed, especially in recycling facilities dealing with WEEE and end-of-life vehicles, where a fire would have a much greater potential for harmful emissions than in other waste management sector areas.

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