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Consequences, Prevention and Extinction of Urban and Industrial Waste Landfill Fires

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ABSTRACT

Among the various types of fire, there are the ones affecting municipal solid waste (MSW), in case of fraudulent "not controlled" fire and the ones affecting industrial waste and materials. The number of rescue interventions to counteract these kinds of fires, carried out by fire services of the countries of the European Union, has substantially increased in recent years, especially in areas where the problem of MSW collection is most felt and where there is a greater presence of industrial plants.

Gas, fumes and vapors that develop during a fire may be responsible for considerable damage both on humans and the environment and, in most cases, mortality due to fire it is caused by the inhalation of these gases, that produce anoxia or toxicity and consequently biological damage. Furthermore, the uncontrolled burning of trash is a major source of pollutants, and it should receive more attention.

In this work, we describe two important experiments carried out on this theme, the first about the emission estimation of a fire in a warehouse of eco-bales and the second about the approximate measurement of pollution resulting from a fire in a tire dump.

In conclusion, landfill fires and their extinction is often framed in the conventional field, but in fact takes on particular characteristics, because of the material concerned and the possible environmental implications, so there is the need to draw up specific fire regulations to be applied to deposits and waste treatment plants and to establish specific operational procedures of fire extinction.

Keywords: Municipal Solid Waste, Tires, Fires, Pollution

1. WASTE FIRES

Among the various types of fire, there are the ones affecting municipal solid waste (MSW), in case of fraudulent "not controlled" and the ones affecting industrial waste and materials. The number of rescue interventions of this kind, carried out by fire services of the countries of the European Union, has substantially increased in recent years, especially in areas where the problem of MSW collection is most felt and where there is a greater presence of industrial plants [1].

This type of intervention, often framed in the conventional field, takes on particular characteristics because of the material concerned, of the facilities and equipment involved (deposits, water treatment etc.) and the possible environmental implications. All this means that this type of intervention is not similar to "ordinary" cases, requiring extensive analysis leading to the identification of adequate procedures and personal protective equipment for the operators involved.

1.1 Hazardous combustion products

Combustion products can be divided into four categories:

- combustion gases;
- flames;
- smoke;
- heat.

Gas, fumes and vapors that develop during a fire may be responsible for considerable damage on both humans and the environment. Smoke is a suspension of particles, consisting of very fine solid particles and condensate steam and constitutes the most visible part of the combustion products. As is well known, epidemiological studies have shown a causal link between presence of particulate matter in the

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atmosphere and a series of effects on human health, including respiratory tract disorders, aggravation of asthmatic disorders, development of chronic bronchitis, decline of pulmonary function, heart disease and development of tumors. The more serious effects of particulate inhalation are caused by finer or soluble particles.

The gas maintains its characteristics even after it has cooled peaking at ambient temperatures. The vapor becomes liquid or solid at temperatures lower than those found in the vicinity of the combustion zone and can, therefore, moving away from the flame, condense and join on cold surfaces or form particles (aerosols) that remain in suspension and they are dragged in the currents. Gases and vapors can cause breathing discomfort, irritation, interactions with external tissues (skin) or internal (nasal mucous membranes, lungs, internal organs and systems), with effects that may vary depending on the hazard of the sub-stance and timing of exposure.

The amount of gases from a fire depends on the type of fuel, the percentage of oxygen and the temperature reached in the fire. In most cases, mortality due to fire it is caused by the inhalation of these gases that produce anoxia or toxicity and consequently biological damage.

1.2 Consequences of waste fires

Heaps of waste materials having a high organic fraction and/or high calorific value are at a considerably high risk of fires; these are commonly used, even though the associated risks are known [3]. Furthermore, it is known that environmental conditions affect the risk of spontaneous fires. In field studies conducted on temporary storage sites, it was found that most of the spontaneous fires broke out after rainfall or after strong winds and in the summer season [4].

The problem of fumes, gases and vapors that develop in case of fire plays an important role especially in the waste management field, in relation to the use, production and storage of substances of potential sources of toxic compounds such as plastic, textiles, paints and polymer materials. When these compounds burn, they release substances, which spread in the air, or on the ground, or in water, contaminating sur-rounding countries and constitute a potential danger to man and the environment. The main gases and vapors cause of human pathological effects present in the combustion products are: carbon monoxide (CO), carbon dioxide (CO_2), hydrogen cyanide (HCN), hydrochloric acid (HCl), nitrogen oxides (N_2O, NO), dioxins (PCCD) and furans.

For most of these compounds, the parameter to be evaluated is the spatial extent of contamination, using various computational models, being an entity related to the composition of compounds, so the toxic effect is temporally linked to the presence of cloud and ceases when the cloud dissolves.

Different speech needs to be done for dioxins. These compounds are, in fact, settling on plants, soil, water are ingested by wildlife that inhabit these areas, accumulating in organisms and thus in the food chain up to the man [2]. Therefore, there is the need to study possible mechanisms of formation of dioxins in order to assess the magnitude and extent of any contamination.

In fact, it is possible to locate potentially dioxin-contaminated area and to detect and quantify the concentration of these substances by analyzing soil samples, using Soxhlet extraction and multistep column cleanup, followed by gas chromatography with high-resolution mass spectrometry (HRGC/HRMS).

Figure 1: A tire landfill fire

1.3 Tire landfill fires

The tires are polymeric materials (45% of their weight consists of elastomer) with a relatively complex structure. The high concentration of organic substance reduced oxidizable substrate and this makes tires susceptible to combustion. Power combustion heater attached to them is relatively high (about 8500 kcal/kg); 1 kg of tires develops the same amount of heat of around 0.7 kg of fuel oil. For these reasons, there are several studies aimed to use them as fuel and, in 1996, already 27 North American cement kilns used tires for that purpose. However, the difficulty of having an auto-ignition, and then the need for pilot flames and the toxicity of the products of their combustion, has certainly contributed to a poor distribution of tires as fuel.

Emissions of toxic and mutagenic products become even more dramatic in the case of uncontrolled combustion. Through laboratory tests, in the fumes of burning tires, were isolated more than 100 organic

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products including light hydrocarbons (methane, acetylene, ethylene, etc.), mono-aromatic compounds (benzene, toluene, xylene, etc.), polycyclic aromatic hydrocarbons (naphthalene, pyrene, phenanthrene), partially oxygenated compounds (naphthol, dibenzofuran, dioxins, etc.) and other heterocyclic compounds. As if that wasn't enough, the discreet presence of sulphur (average 1.5%) and nitrogen (average 0.4%) in the tires is responsible for producing harmful oxides such as SOx (oxides of sulfur) and NOx (nitrogen oxides).

Exposure to smokes with such high concentrations of harmful products can represent both acute and chronic hazards relevant to human health. In particular, risks depend on the time and the degree of exposure, and on average the effects are irritation to skin, eyes and mucous membranes, damage to the central nervous system and the respiratory system, cancer. The United States Environmental Protection Agency (EPA) estimates that emissions from uncontrolled combustion of tires are 13,000 times more mutagenic than coal combustion emissions. However, it is intuitive to think that the concentration of gases emitted depends not only on the composition of the tire, but also on the temperature and the available combustion air.

Figure 2: Refuse Derived Fuel

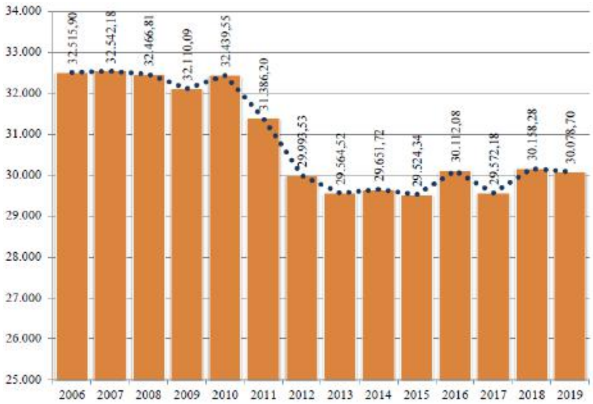

Figure 3: Urban waste production trend in thousands of tons, years 2006 - 2019

2. THE SITUATION IN ITALY AND EUROPE

The 2020 Waste Report published by ISPRA (Italian Higher Institute for Environmental Protection and Research), provides a pretty clear picture of the Italian situation in terms of production and management of municipal solid waste in Italy, pending the publication of the new report. In particular, the current production of urban waste (UW) per capita stood about 1.37 kg per day. The total production of UW in Italy has increased from 2003 to 2006, then remained almost constant, then decreased between 2010 and 2013, and then it started growing again, until has reached, in 2019, the value of 30,078,700 t (Fig. 3). Likewise, the annual production has been increasing over time specification for all national areas, according to an almost linear trend. As regards recycling, most geographical areas show delays relative to the objectives established by law, with Southern Italy that effort yet to reach the limit set in 1999 by the Legislative Decree 5 February 1997 n. 22 (new limits of separate collection until 2012 are imposed by force with the Italian law D.lgs 152/2006). In general, in Italy was registered for the year 2019 a separate collection value in the range of 61,3%.

In particular, the analysis on urban waste management (Fig. 4) shows that the landfill is still one of the most frequent forms of disposal, while composting and especially waste-to-energy policies have difficulty to take off. It should be noted that Refuse-Derived Fuel (RDF) is the product of processing municipal solid waste to separate the non-combustible from the combustible portion, and preparing the combustible portion into a form that can be fired in an existing or new boiler.

In fact, there are two particular positions in Italy:

1) the increasing production of bio-stabilized material and RDF ;
2) the poor development of waste treatment plants in the Campania, Lazio and Sicily regions.

It is important to specify that the bio-stabilization, mechanical-biological treatment process with production of bio-stabilized material and RDF in double flow version, do not configure as a system of treatment, in the sense that the incoming waste is transformed but not treated permanently and downstream further treatment is needed [2].

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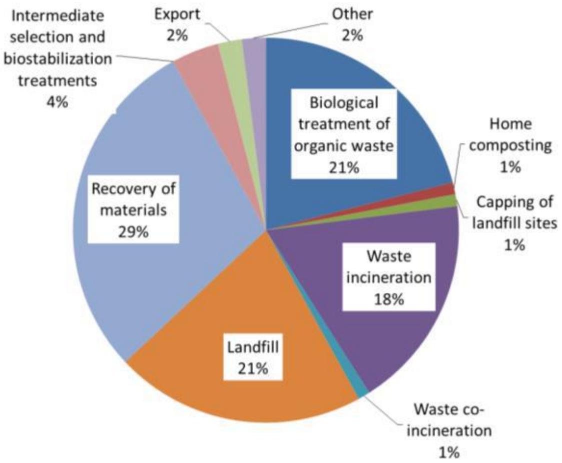

Figure 4: Percentage distribution of urban waste management in 2019

The differentiated collection of the various biodegradable fractions is a fundamental tool for the reduction of landfills of these wastes; in fact, it is clear from the analyzed data that the regions that achieve the best performance in terms of collection are able to easily reach the reduction target.

In some regions such as Campania, Lazio, Sicily, the poor plant development of the infrastructures assigned to the treatment of the organic fraction coming from the separate collection represents an element that is strongly slowing down the implementation of a correct management cycle. For example, in Campania part of the RDF is still stocked in bales in some sites scattered about the region, forming pyramids of height of about 10 m, covered with a tarp in high-density polyethylene (HDPE), because of the absence of one of the two incinerators planned in the design phase of the regional integrated system.

In conclusion, in Italy in 2019 have been dumped in landfill 6,283,000 tons of UW, while the only 37 existing incinerators plants allowed energy recovery from 5,522,000 tons of UW.

3. THE ITALIAN LEGISLATION

Italian law DPR 915/82 for the first time set waste disposal in Italy organically, transposing EU directives n.75/442/CE (on hazardous waste), n.76/403/CE (on the disposal of polychlorinated biphenyls and terphenyls) and n.78/319/CE (on waste in general). The DPR 915/82 is a “framework law” in which we found: the general principles to be respected, the classification of waste, State, regions and municipalities authority, general criteria for the regulation of waste management activities, tax provisions, and financial penalties.

The system established by that Decree was based on the management of waste by deletion of the same activity without enhancing the ability to reuse and recycle. For this and other reasons, the different governments resorted to emergency procedures, designed to limit the production of waste and waste management activities that DPR 915/1982 had neglected to promote.

With the D.lgs n.22/1997, transposing EU directives 91/156/CE on waste, 91/689/CE on hazardous waste and 94/62 on packaging and packaging waste, the legislature, driven by the need to implement in our legal system the new European directives, tried a reorganization of the entire legislation.

Finally, from the entry into force of D.lgs n.152/2006 (incorporating "environmental standards") and the subsequent D.lgs n.205/2010, transposing EU directive 2008/98/CE, Italian legislation on waste has undergone a major transformation: the new measure adopted has reformulated the whole internal legislation on the environment, and has sanctioned the express repeal of D.lgs n.22/1997.

The new rules on waste management are contained in particular in the “part four” of D.lgs n.152/2006, governing the waste management hierarchy, in which are established, as priority actions, to prevent and reduce waste production, followed by recovery activities and, as a last resort, waste disposal.

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As stated in Italian legislation, we can divide the waste into:

a) Municipal Solid Waste (MSW) is urban waste that, although bulky, comes from homes; also included are the waste of any kind or origin, lying on the roads and public areas or on the roads and private areas still subject to public use.
b) Special Waste (SW) is composed mainly of the broad category of industrial waste, agricultural and commercial craft. In addition is considered special waste:
   – waste materials from construction, demolition and excavation;
   – obsolete vehicles and machinery;
   – wastes from hospitals and nursing homes;
   – residues resulting from the treatment of municipal solid waste (incineration residues in waste recycling facilities).
c) Hazardous Waste (HW) includes waste that represents an immediate danger or a danger in the long term, for human health and animal and plant life. The European Union and the scientific literature International attribute the term “Hazardous Wastes”. They are mainly industrial

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waste, which have one or more of the following characteristics:

- Flammability (flame formation at low temperature);
- Toxic/harmful/irritability (acute or chronic health risks);
- Corrosivity (destruction of living tissue);
- Carcinogenicity (cancer malformations);
- Teratogenicity (birth defects, non-hereditary);
- Mutagenicity (hereditary genetic defects);
- Infectivity (diseases to humans because of microorganisms);
- Reactivity/Explosivity (dangerous reaction because of contact with water/air).

Among the compounds that give it character of dangerousness to waste, we can mention the following as an example (for a complete list please consult the Directive EEC 91/689 of 12/12/1991 on hazardous waste):

- chromium compounds;
- lead compounds;
- asbestos (dusts and fibres);
- biocides and plant protection compounds (herbicides, pesticides, etc.);
- infectious substances;
- organo-halogenated compounds;
- PCDD/F (polychlorinated dibenzodioxins and dibenzofurans);
- etc.

Of course, waste danger depends on the concentration of hazardous compounds. For this reason are normally defined concentration limit (C.L.), beyond which the refusal is referred to as hazardous waste.

4. EXPERIMENTS ON WASTE FIRES

4.1 Emission estimation of a fire in a warehouse of eco-bales

In the context of a research performed in 2004 [5], was created an experiment in scale to estimate potential emissions of a full-scale fire on several hundred eco-bales of waste. To evaluate the importance of the proposed experiment, we should remember that in August 2004 and 2005 two RDF storage sites in Campania were the subject of considerable impact fires, especially in relation to the characteristics material burned.

The waste examined in the work cited are those of the city of Lidkoping (Sweden) and surrounding rural areas, packaged and deposited with the city incinerator. The automatic plant processes approximately 800-1000 kg bales, which are using rolls of polyethylene to create an airtight environment. The bales have a diameter of 120 cm and are 120 cm high. The mass depends on the nature of the waste, whose average composition is presented in Table 1.

Table 1. Percentage composition of the eco-bales

Material	Percentage
Paper	28.8
Plastic	11.8
Fabrics, gum, leather	2.7
Glass	1.8
Metals	3.5
Organic	50.8

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In the experiment were used two bales, placed in a covered container and burned using cardboard and 10 liters of diesel fuel. Before the detection of the polluting, the material was made to burn for an hour to allow the flames to stabilize and reduce emissions produced from the combustion of liquid. The fire grew rapidly, facilitated by the presence of the plastics contained in waste and winding of the bales. Where not detected large amounts of smoke and after initial start-up the bales were burned for 2 hours and 50 minutes, monitoring temperature and emissions. The survey results in emissions have highlighted the exceeding of TLV-TWA values for compounds such as sulphur dioxide (SO_2), nitrogen oxides (NO_x), hydrogen chloride (HCl), ammonia (NH_3), Cadmium (Cd), and lead (Pb), cobalt (Co).

The total concentration of polycyclic hydrocarbons (PAH) has been estimated at 3.04 $\mu g/Nm^3$ in the 9% CO_2, dry gas. The total content of PCDD/F varies according to the calculation procedure of the toxic equivalency factor (TEF). Toxic equivalency factor expresses the toxicity of dioxins, furans and PCBs in terms of the most toxic form of dioxin, 2,3,7,8-TCDD. The toxicity of the individual congeners may vary by orders of magnitude. With the TEFs, the toxicity of a mixture of dioxins and dioxin-like compounds can be expressed in a single number: the toxic equivalency (TEQ). It is a single figure resulting from the product of the concentration and individual TEF values of each congener. The TEF/TEQ concept has been developed to facilitate risk assessment and regulatory control. TEF values are given in Table 2.

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Table 2. Concentration in ng/Nm^3 of PCDD/F

Reference	Concentration of PCDD/F (ng/Nm^3)
I-TEF 88	12.53
I-TEF 89	14.09
Eadons	13.86

Note how the values of PCDD/F are exceeding the limits of the European Directive 2000/76/EC on the incineration of waste (transposed in Italy by law D.Lgs. n. 133/2005), equal to 0.1 ng/Nm^3 (average values) and concerning a sampling period of 8 hours.
For the emissions of PAH and PCDD/F, the experiment showed values higher than those found in the literature and this is linked to the fact that the bales were burned at a temperature lower than what occurs In an incinerator or landfill fire. Furthermore, we must not underestimate the fact that the bales were burned inside a container so there might be an incomplete combustion in the absence of oxygen, with significant production of these compounds.

4.2 Pollution resulting from a fire in a tire dump

To estimate the consequences of a tire fire, a research was accomplished using a laboratory reactor in which temperature and airflow are controlled [7]. The fumes that developed by burning a few grams of tire were collected and analyzed through gas chromatography coupled with mass spectroscopy (this is one of the most powerful and versatile coupling between the analytical methods for the study of complex mixtures of volatile compounds). With this technique, it was possible to highlight a different concentration dependence of compounds emitted from the burning of tires as the temperature and the amount of air available for combustion. This parameter is usually indicated by the ratio of the mass of available air and the stoichiometric one required for complete combustion of all material (λ = ν-available / ν- stoichiometric).
This ratio is denoted by the term "bulk air ratio", is crucial in the control of combustion processes in general and is an indicator of the amount of oxygen in the process: values of λ>1 represent combustions that proceed in excess oxygen while for λ=0 the active process is pyrolysis (decomposition without oxygen, heat-induced).
The effect of λ on the emissions of carbon monoxide (CO) and carbon dioxide (CO_2) is typical for the combustion of organic material in General. In particular, the relative amount of carbon dioxide emitted increases progressively with the increasing amount of air present, while carbon monoxide emission has a maximum in correspondence of λ=0.5 (i.e. for a volume of air equal to half of the stoichiometric volume that is required for complete combustion). For values of λ>1 may not appear appreciable concentrations of carbon monoxide [6, 7].
More complex and varied is the emission of volatile organic compounds, which can be classified into three distinct categories in relation to concentrations revealed the variations of air and temperature of 850°C. The three cases are listed below:
1. Compounds which decreases with increasing λ, fall into this category polycyclic aromatic hydrocarbons, which are virtually absent in λ>1.25;
2. Compounds that show an emission maximum around λ=0.5 then virtually absent when the stoichiometric air quantity exceeds that, you fill in this field, partially oxidized compounds such as alcohols, organic acids, furans, ...
3. Compounds that increase in concentration if the amount of air available is higher, typical examples are the aliphatic and starches. Referring to the effect of temperature on products evolved during combustion of tires, there are two distinct classes of compounds:
A) Mono-aromatic hydrocarbons and partially oxidized compounds whose concentration decreases with increasing temperature and are virtually absent for temperatures higher than 1000°C.
B) Polycyclic aromatic hydrocarbons (PAH), which have issued a maximum concentrations around 850°C.
Other recent studies, the behavior of the tires close to the heating to high temperatures, through thermo-gravimetric measurements have been conducted. This technique consists in subjecting the sample to controlled heating and then measure the weight loss, due to the removal of volatile agents. The procedure can be repeated using inert atmosphere (nitrogen) and air, in order to distinguish pyrolytic processes by weight from those due to combustion, characterized by weight losses. The results obtained on some samples show that the tire temperature, at which trigger pyrolytic processes, is equal to about 300°C and that combustion with oxygen uptake can occur only at temperatures above 480°C.

5. FIRES AT WASTE STORAGE PLANTS IN ITALY

Widespread fires frequently hit the waste treatment and storage plants, landfills and illegal areas of the Italian

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territory, which can be more or less serious. For several years, the number of fires classified as "waste fires" has been increasing, up to over twenty-five thousand events per year. In the first half of 2019, just only the landfill fires have been 318, an increased number compared to 210 recorded in the same period of the previous year.

This phenomenon raises a great concern for the population directly and indirectly involved, especially due to the risk of the presence of toxic and harmful substances that can disperse in the surrounding environment. Often, these events are followed by interventions and restrictive orders, adopted by the local authorities, which can entail the closure of schools, Government offices, the temporary stop to fruit and vegetables harvesting, and consequent consumption, or to water drawing for food purposes, from tanks and wells not protected from air downfalls, or the prohibition of grazing and more.

The Parliamentary Commission of Inquiry on the illicit activities linked to the waste cycle has also remarked the great impact on resources involved by the waste management and treatment facilities fires, in terms of firefighting operations carried out by the Italian Fire and Rescue Service and activities for the protection of the population, environmental monitoring and investigation. According to the Commission, this problem suggests or requires proper investment in prevention, which corresponds with an interest concerning not only the environmental protection but also an improved management of the public resources. To have an idea of the scale of the problem, in 318 major events recorded in the first half of 2019, the Italian firefighters employed their own personnel and vehicles for over 856 hours, with an average of 43.46 worked hours for each firefighter.

6. SAFETY MEASURES AGAINST WASTE FIRES IN ITALY

The government has undertaken a strong commitment to combat this growing phenomenon, focusing not only on security, but also on safety measures. As provided for by Law No. 281 dated 2018, under art. 26 bis, the preparation of an internal emergency plan is required for any waste storage and processing plants. The managers of these existing or newly built plants are hence obliged to draw up an internal emergency plan and transmit any useful information to the relevant prefect for the external emergency plan whose preparation and implementation will then be up to the prefect, in agreement with the Regions and local authorities involved. This provision, which was also adopted in the wake of the increasing problem of the waste fires due to arson, especially in some areas of the territory, comes after the creation of the Memorandum of Understanding (MoU) between the Presidency of the Council of Ministers and Campania Region. The MoU experimentally establishes an action plan against waste fires, with the development of three fields of intervention: safeguard of the population health, environmental and ecosystem protection, monitoring and control of the territory and prevention of waste fires.

Among the first consequences, the need arose to modify the above-mentioned article 26 bis, to incorporate the observations and best practices that emerged from the administrations and institutions involved. In particular, if amended, the standard should provide for the obligation, on the managers of existing or newly built plants of waste storage and treatment, to draw up an internal emergency plan. Indeed, while pursuing the aim of protecting the health and safety of workplaces, including waste storage and treatment sites, the preparation of an adequate emergency response plan represents a key factor.

The internal emergency plan will aim at the implementation of all necessary measures to control and limit the incidents that could cause changes in the environ-mental matrices, to minimize their effects and reduce consequent damage to human health, environment and goods. It will also contribute to properly informing workers, emergency services and the competent local authorities. Finally, in case of an accident, it shall provide for the site restoration and clean-up.

The target behind the need to provide for guidelines is the homogenization of the planning method, which has to be adapted to the different territorial areas, for the management of the accidents effects.

The purposes of the external emergency plan are numerous: first of all, the control and mitigation of accidents, in order to minimize their effects and limit consequent damage to human health, environment and property. It will also have the function to implement all necessary measures to protect human and environmental health from accidents consequences, to adequately inform the population, the emergency services and competent local authorities and to ensure, according to the provisions in force, the site restoration and clean-up after an accident.

In 2019, the Ministry for the Environment and the Italian Fire and Rescue Service have given the first

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direction concerning the information that the waste plants managers must provide to the prefects, as well as the minimum contents that an internal emergency plan should include. Finally, with the Decree of the President of the Council of Ministers of 27 August 2021 [8], the "Guidelines for the preparation of the external emergency plan and for the relative information of the population for waste storage and treatment plants" were approved.

7. CONCLUSIONS

The analysis described shows that it is essential to consider the need to draw up specific fire regulations to be applied to deposits and waste treatment plants. However, this must be done taking into account the characteristics of the materials reviewed, in order to prevent these type of fires. There is also the need to draw up specific operational procedures of firefighter's intervention, with particular reference to PPE (personal protective equipment) and extinguishing techniques.

It is also important to dedicate a few words to the control and extinction of tire fires, given the existence of specific complications, in addition to the risks associated with the toxicity of emissions already displayed. The particular shape of tires makes it extremely complicated to reach the entire surface combustion of extinguishers, and allows air to pinch and then continue to fuel combustion. The high thermal irradiation is a further element of difficulty. As in any case the most effective remedy is certainly "prevention", however, in cases where the fire is taking place, the guidelines provided by EPA for such fires are burning insulation material and its immediate extinction by immersion in water. Alternatively, it possible to use water spray, in case that isn't available a reserve of water for the immersion of the tires, but the use of a stream of water directed proved to be less effective.

In many cases the control of fire was executed by smothering the combustion with filling material (sand, for example), but in these cases it is possible to obtain highly harmful fumes and lasting chemical reactions that require continuous monitoring and monitoring of gases emitted for a few weeks. The toxicity of these fumes is related to the presence of high concentrations of polycyclic aromatic hydrocarbons (carcinogens), whose emissions increase when the amount of air available is poor ($\lambda > 1$), as shown before.

The frequent episodes of fire that in recent times have affected in Italy the waste management and treatment plants have given rise to strong concerns in the community, both due to the particular nature of the environmental matrices involved, and in consideration of the impacts associated with the events, very often of considerable entity. Therefore, in Italy, to adequately deal with accident scenarios, the managers of existing or newly built waste storage and processing plants are required to draw up an internal emergency plan (IEP). In addition, for the same plants, the local prefect must prepare the external emergency plan (EEP), in agreement with the regions and the local authorities concerned, taking into account the information provided by the managers of the aforementioned activities.

The EEP is prepared following specific guidelines. The objectives that an EEP must pursue, to be compliant with the guidelines are summarized as follows:

– control and mitigation of the effects produced by accidents
– implementation of the necessary measures to protect humans, the environment and property from the consequences of accidents
– prior information to the population and to the competent local Authorities about the procedures established for the protection of public safety
– restoration and cleaning of the environment.

In conclusion, despite the efforts made to date to fight waste fires, given the importance of this issue, it is clear that further research is needed and the current regulations and controls on storage and treatment plants still need to be improved.

8. ACRONYMS

EEP: external emergency plan
EPA: United States Environmental Protection Agency
HDPE: high-density polyethylene
HW: Hazardous Waste
IEP: internal emergency plan
IFRS: Italian Fire and Rescue Service
ISPRA: Italian Higher Institute for Environmental Protection and Research
MSW: Municipal Solid Waste
PAH: polycyclic aromatic hydrocarbons
PCDD/F: polychlorinated dibenzodioxins and dibenzofurans
PPE: Personal Protective Equipment
RDF: Refuse-Derived Fuel
SW: Special Waste
TEF: Toxic Equivalency Factor
TLV-TWA: Threshold Limit Value - Time Weighted Average
UW: Urban Waste

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