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FIRES IN ORGANIC WASTE STORAGES: PREVENTION, FIRE FIGHTING AND AFTER CARE

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ABSTRACT

The development of each fire in a solid waste storage area is unique and depends on the type of material stored, the design and type of storage, the weather conditions and moisture content, the way the initial phase of the fire is handled, the type and quantity of equipment and material available for extinguishing the fire, and the number and level of trained personnel available. This paper describes briefly two large fire events occurring in two waste storage areas: one registered as two consecutive events in Sweden (2006) where the waste was stored as hardly-compacted heaps; and one in Denmark (2005) where the waste was stored in round bales with plastic. Best practices to avoid fire events in waste storages, as well as the experience and knowledge acquired during fighting of these fires and handling of remained material are presented. Recommendations based on lessons learned are presented.

KEYWORDS

Combustible waste; Storage of waste as fuel; Self ignition; Fire brigade; Baled waste.

1 INTRODUCTION

The amount of the organic waste and recovery material has increased during recent years in EU countries, as a consequence of the EU Council Directive 99/31/EC of 26 April 1999 on the landfill of waste. As a result, the number of incinerators in Sweden has raised from 21 to 29 from year 2000 to 2006, and large storage of waste fuels have been kept during the period for construction of new and reconstruction of old facilities. The waste fractions are also sorted in a higher degree and heaps of organic materials are stored in very large amounts, usually with no proper care. One of the consequences of this increasing storage of waste is that many fires have occurred in Sweden as well as in other EU countries at landfills, at temporary storages of recyclables, storages of hazardous material and waste as fuel [1]. During 2002, for instance, 69 landfill fires occurred in 49 different landfills in Sweden (RVF, 2003). The Swedish Rescue Services Agency [2] reports 70-80 fires per year in the range of 500 to 2000

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m^2, being 20 of these fires considered large events. Some few times, these events are very large and reach 20 000 tons of waste or even more. In very large events, the emissions to the air including large amounts of particulates toxic gases represent a risk to human health and the environment. The water used for extinguishing the fire usually floods the leachate collection and drainage systems and in the worst case, pollutes the ground and the surface water.

1.1 Processes involved in self-ignition

Storage tests with different kinds of organic materials show that temperature increases in storage areas through self-heating processes [3]. Self-heating can lead to self-ignition after a few days or after a month or half a year or more. Self-ignition is an exothermic process (e.g., an energy supply is needed) which requires the following conditions: (a) existence of burnable material, (b) an increased temperature, (c) available oxygen, (d) favourable moisture content in the range of 20-40%. The phenomenon is usually defined as a flow/diffusion process where the transport of moisture, heat and oxygen is the most important mechanism. Some metals, such as iron, can act as catalysts for the heating process and can therefore increase the risk of self-ignition. At low temperatures, adsorption in the liquid phase is important for self-heating. The speed with which the temperature increases in the stored organic material (e.g.: waste) depends on the composition, moisture and temperature of the surroundings. The temperature increase starts in the interior of the storage heap that has the best insulation. When water vapour reaches the upper parts of the storage heap, where the temperature is lower, condensation occurs. The most important risk factor for self-ignition is where heat is concentrated in a condensation zone. This will be especially dangerous in areas that have dried up because of high temperatures and remained dry for a long time and then suddenly experience an influx of moist air. In this context, the four steps of the fire ladder can be considered [4]. The steps are in order of increasing self ignition risk. Biological heat generation, usually dominates in the temperature range 35-80ºC [5], pyrolysis in the range of 80-150ºC [5]; smoldering between 150-315ºC [5, 6] and ignition above 315ºC [7]. One important parameter influencing the type of mechanism that dominates is the moisture content of the waste [5, 8]. Moisture content above 40-45% seems to be sufficient to keep the temperature down [9]. Moisture in the range of 20-40% is considered as spontaneous ignition risk zone. Moisture can cool the waste but it can also promote exothermic processes [10], for example in lignocellulose, leading to increased temperatures and thus higher risk for self ignition [4]. The concept of the fire ladder fits with observations in previous studies [3]. In principle, baled waste (as the case of the storage at Ålborg, Denmark) should have less risk for self ignition than compacted waste (as the case of the storage at Telge, Sweden), since once the waste has been baled, the moisture content is reduced to the range of 40-50% [11, 12].

1.2 Current practices at waste management companies

Small fire events are usually handled by the personnel of the waste management company and in these cases, the fire brigade is not contacted. Only in large fires, the fire brigade is involved in the extinguishment. The waste management companies are commonly equipped with water hydrants, protective clothing, pumps and water hoses, a system of water pipes and fire ponds, among other components, so that its staff can make a significant contribution towards fighting the fire. Based on verbal reports from managers that were interviewed, the division of responsibilities between the waste management company and the fire brigade in deciding who is in charge of fighting the fire is currently unclear. Often, waste management companies have some contingency plan for fire fighting and the personnel trained for fire fighting and

sometimes together with the fire brigade. The companies also have insurance covering accidently fires of material, buildings and equipment, including fire boxes with fire fighting appliance. Fires in storage are usually first detected due to slight grey-blue smoke coming up from one or several points of the storage. An old way of extinguishing this type of fire on a early stage has been to spread out the waste with a load where the fire has been identified and run over the area carefully with the compactor or alternatively, cover the storage with a 0.5 m of clay preferable or other soil material.

2 FIRE EVENTS IN WASTE STORAGES NEAR STOCKHOLM, SWEDEN

Telge Återvinning AB is a recycling company, located near Stockholm, Sweden that transports, collects, sorts, treats and recycles solid waste, but also operates landfill. The company - which is owned by the municipality - has ISO 14001 certificate and also working environment certificate according to AFS 2001:1. All waste material entering the plant is weighted at the weight bridge, registered and classified. In this plant, household waste is treated biologically and ashes are landfilled separately; hazardous wastes are sorted for treatment, industrial waste is sorted for material recovery, construction and demolition waste is sorted and upgraded to high quality fuel. The methane gas generated is collected for production of district heating.

A highly compacted storage for waste as fuel that started in April 2006 at Telge Återvinning AB had reached in August a volume of 50 000 m^3, corresponding to about 12 000 tonnes of burnable organic material with height of 8 to 10 m, according to internal documentation from Södertörn Fire and Rescue Service [13]. The report mentioned that 16 000 m^3 laid up in a storage of ca 200 m x 70 m x 8-10 m height.

The fire fighting was carried out during the period of 9-27 August 2006 divided into two fire events, according to the company. The first event occurred during 9-12 of August and the second, during 17-21 August, after the first fire had destroyed about half of the storage (ca. 8 000 m^3).

This type of storage is constructed by laying down the waste in layers of 30 to 50 cm. After that, compaction with 3-4 turns is carried out with a compactor. It is important that compaction is equally achieved in the whole storage, in order to reduce as much as possible the differences in density in the storage heap, reducing risks for self ignition. The side slopes shall be carefully compacted in order to avoid inflow of air and that stands for all wind directions. The information given by the company, which was relevant to the understanding of the fire occurrence, is that the bottom layer up to about 3-4 m had not been compacted with compactor.

The fire fighting by the rescue service at Telge included two periodsa 9 to 12 and 17 to 21 August, 2006. During the fire fighting period, 383 man-hours were used in the fighting phase and in the post-fighting phase 610 man-hours were needed. During the second event, 472 man-hours were used during fighting and 412 man-hours were used in the post-fighting phase. Telge Recycling AB decided to hire personnel from the fire brigade for the post-fighting phase in both cases. *Table 1* show the material used during the two fire events.

Table 1. Material used at Telge Återvinning during two fire fighting periods.

Material used	Amount/number
First fire event (9-12 Aug 06)	
Course water hose	2500 m
Water sprinklers	25
Steel pipes	10
Water hydrants	4
Tank trucks	2
Second fire event (17-21 Aug 06)	
"Civil defence pipes"	1200 m
Course waters hose	3400 m
Water hydrants	8
Foam liquid (detergent a 10 kr/L)	4400 L
Water sprinklers	15
Tank trucks	3
Excavators	3
Forest fire container	1

3 FIRE EVENTS IN A WASTE STORAGE IN ÅLBORG, DENMARK

A storage fire occurring during September 2005 at CemMiljö A/S, Ålborg, Denmark has been previously described [14, 15]. The company imports unsorted municipal solid waste from Germany, Norway and Sweden. In that site, baled waste storage area had about 12 000 tonnes of waste (common storage volumes have about 5 000 tonnes, which is equivalent to three weeks of incineration capacity) covering an area of 8 000 m^2, which was fenced by a 3.5–4 m high soil embankment. The fire spread very fast, so the staff of the waste management company had no chance of fighting it. Extinguishing the fire took more than 24 h and smoke could be seen from the storage area for three weeks after the fire was detected. Several attempts were made to combat the fire using water wagons, which had a capacity of 2000 L min-1, but the temperature was too high, preventing the squad from getting close enough to the fire. The cost of extinguishing the fire was about US$ 130 000. Thirteen dumpers, three excavators and two bulldozers were used when the fire brigade tried to cover the fire with a wet soil mixture consisting of clay, lime and soil, to a thickness of about one meter. The direct cost of the fire was US$ 500 000, but the total cost was US$ 1 250 000, including construction of a new storage area for waste and waste fuels.

4 BEST MANAGEMENT PRACTICES

4.1 Prevention of self ignition

In order to avoid self ignition and large fires, it is recommended: (i) to store loose heaps of waste in smaller amounts and for shorter periods and keep it at a distance from waste fuel storage; (ii) to prevent fires spreading to storage areas from adjacent fires; (iii) to extinguish fires in storage areas with wet earth rather than a water gun; (iv) to build up firebreaks to reduce large storage areas, which makes difficult to access the places where the fire started and slow down the fire spreading; (v) to have one professional only responsible for public information to avoid conflict of information; (vi) to train the waste management personnel about fire-fighting and how to avoid fires; (vii) to discuss with fire brigade and authorities

about available storage techniques, associated risks of fire, fire prevention and extinguishing strategies.

The storage cells should be surrounded by 4-m-high walls; cells wider than 10–15 m and longer than 50 m should be avoided; each cell should not contain more than 1 000 tonnes of compacted/ baled material. The most common way to extinguish the fire is to use water and water hose systems, making fire breaks, excavated the material and moist it in water ponds/ dams, use foam or wet soil masses to smother the fire.

4.2 Fire breaks

In order to avoid spreading of the fire to parts of the storage area that are considered not to be in fire, those parts are usually sprayed with water, to avoid spreading igniting sparks from the area of fire. The effect of this type of operation can be questioned thus, it change the pressure and composition of the gases as well the living conditions for the microorganisms inside the heap that can cause a future self ignition. The fire break is excavated with excavators, front loaders and dumpers to a certain width. Breaks avoid direct spreading of the fire and reduce the risk for top spreading by the flames and/or by igniting sparks. The development of smoke from the fire can be a hinder for the excavation but can be reduced by spraying foam that also act as an effective fire-fighting medium when applied in the optimum concentration. The risk when digging a fire lane is the danger for the personnel that will be in contact with toxic gases and smoke if they are not protected properly and with machines can be caught by the fire. When breaks are created, air is coming into the waste and areas with high temperature and areas that might be in early stage of pyrolysis and this can cause a new open fire. After excavation, the slopes of the fire break should be compacted in order to avoid air entering the storage from a new angle resulting from the wind. An alternative to fire breaks is to spray the same area with large amounts of water, which reduce the fire spreading.

4.3 Excavation and watering of the waste masses

An alternative to cover the storage with in order to reduce/avoid the spreading of the fire is to excavate the area where smoke or fire is visible. When the excavation starts, the air enters and the flames might be visible. The excavated burning waste can be sprayed with large amount of water or submersed into a water pond. The pond might be constructed before any fire occurs as a preventive strategy or dug out on site during the fire. Natural ponds and lakes should be avoided due to obvious environmental reasons. For the fire fighting, the municipal drinking water net can be used if the water capacity at the site is big enough. Water can be taken from a lake or a river nearby but after using it, the water will be heavily polluted and cannot be discharged back into the water body. Stormwater and sometimes leachate from the landfill can be used. At Telge, 17 000 m^3 of water was used, which correspond to about 1/3 of the annual leachate production at the landfill. Emissions to the air when leachate and stormwater are used for fire fighting must be assessed.

4.4 Remaining material

The waste management companies have insurance for their property and activities. Therefore, the insurance company makes an investigation of the area of the fire afterwards including the storage size, material stored, way it caught fire, the fire fighting, among other aspects and makes a report about the case. They also try to classify the remaining material after the fire and establish its economic value. If the extent of the fire is limited and it has been possible, for instant, to cover a dominating part of the storage with soil, it might be possible to recover part of the fuel with still high calorific value. In many cases the fire process has gone too far

and the material is additionally affected by the fire fighting. The storage material includes a lot of ash, sand and scrap mixed with organic material. The question raised after the fire is extinguished is related to the final disposal of the remaining material. A decision shall be taken regarding if the material can be landfilled according to the EU-directive in a non-hazardous landfill or if it can be used for filling during civil construction or if it needs to be treated with a more expensive procedure due to its hazardousness. A question to be addressed that has legal consequences is how this type of fire generates environmental effects on land, air, surface and ground waters during the fire, during the fire fighting, and after the final handling of the remaining material. The law for protection of accidents in Sweden 2003a778 and SRVFS 2004:3, for instance, are applicable.

4.5 The man in charge

Fire-fighting squad or fire-fighters although very well organized and trained for the work, they are mostly trained for fires in flats and buildings. Fires in waste fuel storages are different. As always there is a need of good organization that must be shared between the rescue service and the waste management company. During the pre-fire period and the initial stage of the fire (before the fire-brigade is called) one professional at the waste management company properly trained to cooperate with the fire-fighting squad must be in charge during the whole operation period. When the fire fighting squad arrives they take over the leadership of the organization. There must be a clear and effective communication between the staff command officer for the fire fighter and the company manager in order to manage the operative planning on site for the fire fighting with the two teams. A good strategy for effective use of material and staff is crucial for a good and fast result in this type of work. At least two meetings per day are recommended and all actions as well as staff and material used should be documented. When the staff command officer in communication with the company manger considers that the critical situation is over, the company staff takes over the control of the operations for the post-fighting period until the fire is totally extinguished. Only one person must be responsible for the communication with the media in order to not giving confusing and contradictory messages. The information to the citizens should be correct and balanced to avoid panic and other physiological effects that can occur parallel to respiratory and asthmatic problems due to smoke and toxic gases when the wind from the fire is in direction to urban areas.

5 FINAL RECOMMENDATIONS

In order to reduce the risk of fires in storages of waste, several preventive actions must be taken, such as: a contingence plan and trained personnel is the first requirement; Material that facilitates self ignition must be sorted out; storage must be well compacted to minimize air inflow; , the size of the stockpiles must be kept small and with a safe corridor in between; safe distance from buildings and from areas with long grass and reeds must be kept; lighting of cigarettes, etc shall be avoided; monitoring of temperature and weather conditions must be done; when the temperature increases the storage shall be capped with soil, preferably moraine clay; easy access of fire fighting machines must be guaranteed.

To extinguish fires in bale storage areas, the use of wet earth rather than water hydrants should be considered, as water hydrants are a less efficient extinguishing method. Fire breaks should be built in bale storage areas to reduce the construction of large and continuous heaps, thus reducing the chances for early detection and making more difficult the access to the point where fire started. Detergent foam, aqueous film-forming foam, etc can be used with satisfactory results if they it is mixed in proper concentrations.

The development of smoke is expected to vary according to the composition of the burning waste material. Compacted storages containing paper, wood and cardboard give a blue grey smoke when burning, meanwhile storages constructed with plastic bales give sooty and black smoke that one cannot see through and the combustion process is often incomplete.

Generally the waste fires produce toxic smoke and gases that contains particulate matter that can cause respiratory distress. Thus the danger and the toxicity of the gases is related to the time of exposure the fire-fighters and the personnel form the waste company involved should not too many working hours without possibility to recover. In the case the smoke is drifting into urban areas windows should be kept shut and people with allergies and asthmatic diseases should be evacuated. The manager of the storage facility should, together with the current fire authorities, determine a suitable technology for extinguishing fires as well as determining the status of the current volume of earth that can be used to extinguish a possible fire.

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