



Assessment of Fire Incidents in Jordan (2008-2014)

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Abstract-Incidents in Jordan reported to the Public Fire Brigade during 2008-2014 involving fires are investigated. A detailed analysis of about 131,000 accidents covering all types of fire is presented. Statistical comparisons are made based on the type of accidents and its accompanying deaths and injuries. The results obtained illustrated that half of the total number of incidents are wild land and farms and other 30% were accounted for used tyres and solid waste and residential homes together. Between 2012 and 2014 electrical wiring and equipment were responsible for more than 40% of fire incidents in residential homes.

Keywords- Fires, Incidents, Causes, Jordan

I. INTRODUCTION

Fire is the combustion of materials; the fire triangle identifies the three essential components of fire:

1. Fuel
2. Heat
3. Air

Fire will keep burning until one or two components are depleted. The chain reaction has been added to the fire triangle. This addition produced the fire tetrahedron and its purpose is to sustain the fire. The fire always occurs in the vapor phase, liquids are volatilized and solids are decomposed into vapor prior to combustion.

The stages of fire are summarized as follows [1]:

1. Ignition: the three components of the fire triangle are joined together in a sustained chemical reaction.
2. Growth: the flame acts as a heat source to ignite more fuels. The heat is transmitted through conduction, radiation and convection.
3. Fully developed: almost all the available fuel is burning, and the temperature is at its highest value.
4. Decay: the fuel is consumed and the temperature decreased rapidly.

Fires usually classified according to fuel type [1]:

1. Class A: ordinary flammable material (wood, paper, etc.).

2. Class B: flammable liquids (petroleum).
3. Class C: energized electrical equipment.
4. Class D: metals (magnesium, potassium, etc.).
5. Class K: cooking oil and fats.

NFPA 921 considered the cause of a fire as the basis of fire categories [2]:

1. Accidental: unintentional human act to ignite a fuel.
2. Incendiary: intentional human act to ignite a flammable material.
3. Natural: no human intervention
4. Undetermined: the cause is still under investigation.

More literature on the subject of fire, its characteristics, smoke, flame and environmental damage is published in such References [3-6].

Each year, Jordan witnesses a number of fire incidents which results in deaths, injuries and losses of property occurring in different locations. The main source of records and statistics on fire is the Public Fire Brigades (PFB). The published records are only of those fires which were attended by the PFB. Some of the major duties of the PFB is to investigate accidents, to determine the cause of the fire and to recommend methods to prevent similar accidents from occurring again.

The published records may be used to create a baseline for evaluating existing programs, motivate research and to set priorities.

Sweis [7] in his extensive study of fire incidents in Jordan for the period 1996-2004, provided a detailed analysis on the type of accidents, the causes of fires and the number of fatalities and injuries associated with each incident. He concluded that wild land and residential homes fires contributed to about 70% of the total number of accidents occurred.

In order to give a thorough analysis and to assess the attitude of the parameters of the accident for the years following the 1996-2004 period, this paper presents an analysis of fire incidents attended by the PFB in Jordan during the period 2008- 2014.

II. STRUCTURE

The accidents studied in this paper occurred in the period 1 January 2008 to 31 December 2014. These incidents produced fires (flame) and were attended by the PFB [8].

The reported accidents by the PFB have been regrouped into several categories as shown in Table 1. The table shows the number of incidents occurred together with the total number of injuries and fatalities. The table illustrates the followings:

- The wild land, used tyres and solid waste and home fires produced the highest number of incidents occurred for the last seven years, respectively.
- The home fires and the motor vehicles and petroleum tanker's had the highest number of deaths for the last seven years, respectively.

III. NUMBER OF FIRES PER YEAR (2008-2014)

The overall numbers of reported accidents in these categories together with the percentage of occurrence and the number of injuries and fatalities for each year are presented in Table 2. The categories were listed according to the decreasing number of accidents. Others category, was on the bottom of the table because it consists of many sources, such as, kiosks, poultry farms, cattle sheds, tents, etc. .

Fire incidents are considered high in Jordan. The table shows that the total numbers of incidents reported were 130747 which resulted in 7080 injuries and 239 fatalities over the period 2008-2014. The annual average of fires, which occurred between 2008-2010 and 2012-2014 were 14162 and 22967, respectively. This shows that the fire frequency is increasing sharply over the period 2012-2014, whereas in 2014, the frequency of fires decreased by about 19% on the previous year's figure.

TABLE I. CATEGORIES OF ACCIDENTS (2008 -2014)

Category	Numbers		
	Incidents	Injuries	Fatalities
Wild land and farms	65101	438	1
Used tyres and solid waste	22853	161	0
Residential homes	16515	3670	131
Motor vehicles and petroleum tankers	9567	621	48
Commercial and business places	4809	973	2
Industrial plants and storage places	3488	643	4
Transformers and power machines	3113	88	0
Others (miscellaneous)	5301	486	23
Total	130747	7080	239

TABLE II. STATISTICS OF FIRE IN JORDAN (2008-2014)

Category	Year						
	2008	2009	2010	2011	2012	2013	2014
Residential homes							
Incidents	1901	2166	2157	2291	2491	2606	2903
Percentage	17.1	17.4	10.7	11.4	10.4	10.2	14
Injuries	417	523	463	481	505	611	670
Fatalities	17	24	19	22	28	17	26
Industrial plants and storage places							
Incidents	493	455	510	457	485	554	534
Percentage	4.4	3.7	2.5	2.3	2.1	2.2	2.6
Injuries	88	72	83	95	136	70	99
Fatalities	1	0	3	0	0	0	0
Wild land and farms							
Incidents	3951	4686	11610	10545	12650	13448	8211
Percentage	35.5	37.7	57.5	52.4	52.7	52.5	39.5
Injuries	37	25	124	82	60	92	18
Fatalities	0	0	0	0	0	1	0
Motor vehicles and petroleum tankers							
Incidents	1010	1162	1265	1356	1554	1631	1589
Percentage	9.1	9.4	6.3	6.7	6.5	6.4	7.6
Injuries	90	77	96	90	93	84	91
Fatalities	16	6	8	7	7	6	5
Used tyres and solid waste							
Incidents	2178	2342	2650	2955	3733	4275	4720
Percentage	19.6	18.9	13.2	14.7	15.6	16.7	22.7
Injuries	13	15	50	31	20	17	15
Fatalities	0	0	0	0	0	0	0
Commercial and business places							
Incidents	629	607	614	638	727	753	841
Percentage	5.7	4.8	3.1	3.2	3.1	2.9	4.1
Injuries	212	85	75	123	162	187	129
Fatalities	0	0	1	0	0	0	1
Transformers and power machines							
Incidents	236	243	306	361	540	634	793
Percentage	2.1	2	1.5	1.8	2.3	2.4	3.8
Injuries	7	14	13	11	9	19	15
Fatalities	0	0	1	0	0	0	0
Others							
Incidents	313	391	612	755	1130	1231	869
Percentage	2.8	3.2	3	3.7	4.6	4.7	4.1
Injuries	32	25	44	73	92	124	96
Fatalities	1	1	0	1	7	11	3
Total							
Incidents	10711	12052	19724	19358	23310	25132	20460
Percentage	100	100	100	100	100	100	100
Injuries	896	836	948	986	1077	1204	1133
Fatalities	35	31	31	30	42	35	35

IV. RESIDENTIAL HOMES

The reported incidents in this category averaged out to 2360 fires per year (Table 2). In general, the number of residential fires in 2014 increased by 35% on the 2008 figure. It can be seen that in 2012-2014 period, the average number of injuries increased moderately by 21% of the average figure obtained for the 2008-2010 period. The fatalities fluctuated for the whole period. The total number of fatalities for the seven year period was 131, whereas the highest number of fatalities occurred in 2012 (28 deaths).

The causes of home fires and their percentage of occurrence for a total of 8000 incidents that occurred in the years 2012, 2013 and 2014 are presented in Table 3 [8]. The table shows that electrical wiring and equipment, arson and children carelessness were identified as the major causes of a number of incidents. These causes also contributed to about 75 % of all the causes. The three causes resulted in 1786 injuries and 71 deaths. Gas leak results in fire increases in winter season; this is due to the increase usage of gas heaters.

TABLE III. CAUSES OF HOME FIRES IN 2012 - 2014

Types of ignition source	Percentage of occurrence		
	2012	2013	2014
Electrical wiring and equipment	43.7	43.9	42.9
Arson	18.4	20.2	22.9
Children carelessness	12.8	12.9	10.8
Gas leak	7.5	7.1	8.9
Negligence	10.9	9.3	8.5
Heaters	2.7	2.2	1.4
Smoking	1.3	0.8	0.8
Others	2.7	3.4	3.8

In 2014, electrical wiring and equipment was identified as the cause of a 42.9% of home incidents even where the hazard was well understood in advance, the incident may be attributed to many causes, such as, the lack of detailed local codes, lack of maintenance and the extra load on circuit breakers, etc.

Many of the home incidents cause no injuries to the occupants, but may cause damage to the place where the incident occurred.

V. INDUSTRIAL PLANTS AND STORAGE PLACES

The type of industries in this category involved is wide, and includes chemicals, textiles, paper and cartons, paints, fertilizers, foods and furniture, etc.

The reported incidents of this category include all types of industrial and process plants together with its storage places. These incidents were attended by the PFB. It is common for the larger industrial plants to have their own fire engines and as a result, many fire incidents are not reported to the PFB. Without these records, a complete picture of the fire hazards in the industrial section cannot be drawn.

Table 2 shows that, there is an insignificant variation in the number of incidents over the entire period. The table indicates that in 2012-2014, the average number of incidents has risen to more than 7% of the average number of 2008-2010 figures. The number of incidents in 2014 decreased by about 4% of that figure reported in 2013. The average number of injuries in 2012-2014 has increased by about 21% of that average figure recorded in 2008-2010. The number of fatalities recorded was insignificant throughout the years, this may be attributed to the high quality and strict control of process safety and loss prevention applied in the plant.

Usually the contribution of storage places to fire is high, this is may be attributed to the lack of proper storage procedure, and not following the storage codes. In one accident, demonstrating negligence that many people have with regards to the storage of hazardous materials, 7 people were injured and hospitalized. This incident occurred when a three story building was used to store petroleum liquids, paints, vehicle motors, motors oil and wood etc. All these materials were stored in an unorganized pattern where the least of protection (separation) was not applied.

VI. WILD LAND AND FARMS

The number of incidents in the wild land and farm category is always high. This category claimed about 50% of the total number of fire incidents occurred in the seven year period. The total number of incidents in 2014 showed a decrease on the previous year's figure by almost 40%. The total number of injuries was 438 and only one fatality counted over the seven years period (Table 2).

In 2013, the highest number of incidents occurred [8]. These incidents covered about 7000 acres, destroying around 56000 trees. The largest number of incidents resulted from arson, children carelessness and smoking. Table 4 lists the causes of fires and their percentage of occurrence for 13448 incidents.

TABLE IV. CAUSES OF WILD LAND AND FARMS FIRES IN 2013

Type	Percentage of occurrence
Arson	77
Children carelessness	16.4
Smoking	4.2
Electrical wiring	0.7
Negligence	0.6
Sparks	0.1
Other	1

Arson remains a serious and substantial risk to many of the mentioned categories. Arson act may be based on personal issues, financial issues or other motives. Coal is usually used for B.B.C outside residential homes. If this material is not handled properly, it will become a cause of uncontrolled fire. Also, fire is always used to reduce vegetation cover and land

cleaning. A large number of incidents will result from escaped small scale agricultural burns.

VII. MOTOR VEHICLES AND PETROLEUM TANKERS

This category covers vehicle fires and road traffic accidents which escalated into fires. It includes vehicles carrying passengers and petrol tankers transporting petrol products to customers around the country.

Table 2 illustrates that the number of incidents continue to show an upward trend. The total number of incidents in 2014 showed an increase on the 2008 figure by 36%. For the seven year period, the number of injuries and fatalities were 621 and 55, respectively. The number of fatalities resulted from motor vehicles and those from residential homes are the highest amongst all recorded in other categories.

Usually, the petrol tankers are associated with a small proportion of overall incidents reported in any year. In 2014 [8], its association was only 0.1 %, yet these incidents were responsible for many injuries and deaths. Lack of proper maintenance and more specifically brake failure are usually common causes of losing the control of a tanker. In 2010, a fire started in a tanker carrying crude oil, the driver decided to take the tanker to the parking area where other tankers were parked. The tanker was uncontrolled, and the fire was propagated to other petrol vehicles, and this incident resulted in 3 fatalities and 9 injuries.

VIII. USED TYRES AND SOLID WASTE

This category includes used tyres and solid waste, stored either in an open or closed area.

The number of incidents in this category is increasing every year. In 2014 the number is more than doubled the number recorded in 2008. Although, this type of fire accounted for the highest percentage (22.7%) of the total number of fires occurred in 2014 (Table 2). For the seven years period, there is a significant record of associated injuries (161), but fortunately no one was killed.

In 2012 [8], the percentage of this category fires was 2.7% of the total fires. Arson and children carelessness were identified to be the causes of a significant number of fires. In a significant incident that occurred in 2014, a company stored used tyres adjacent to a four story residential building used to house their employees. A huge number of the tyres were burnt which resulted in 15 injuries.

IX. COMMERCIAL AND BUSINESS PLACES

The reported incidents of this category includes all kinds of commercial and business places, for example, commercials malls, offices, hospitals, banks, hotels, etc.

Table 2 shows that, in 2012-2014, the average number of incidents has risen to more than 20% of the average number of 2008-2010 figures. The total number of injuries for the seven

years period was 973, but the number of injuries in 2014 has fallen by about 31% of the number recorded in 2013. The number of fatalities recorded was only 2 throughout the years.

In 2008, a sterilization section and a record storage room in a maternity hospital were completely burned. This incident resulted in 66 injuries and no fatalities. Seventeen fire brigade vehicles were on the scene to evacuate residents to nearby hospitals. Also in 2010, a shop in a 1400 m² commercial mall was partially burned, but fortunately this incident resulted in one injury.

X. TRANSFORMERS AND POWER MACHINES

The number of incidents in this category (Table 2) continues to show an upward trend. For the period 2008-2014, the total number of incidents was 3113 cases. These incidents resulted in 77 injuries and one fatality. In 2013-2014, the average number of incidents has risen to about 66% of the average number of 2008-2009 figures.

In 2010, an incident occurred in two adjacent transformers, which resulted in one death.

XI. OTHERS

The reported incidents of this category include bakeries, cleaners, kiosks, tents, boats, worship places, etc.

In 2012-2014, the average number of incidents and injuries has risen to about 60% and 67% of the number recorded in 2008-2010, respectively (Table 2). The total number of fatalities for the 2008-2014 period was 24. In 2013, the number of fatalities was 11, it was the highest recorded during the seven years period.

XII. FALSE ALARM

Usually this category is a waste of effort, time and money and may help in reducing the efficiency of the fire brigade force in providing the necessary help when it is needed. The PFB records indicate that there were 3501 false alarm during the period 2008-2014. This category was not included in any issue related to this analysis.

XIII. DISCUSSION

Jordan Insurance federation (JOIF) [9] publishes a yearly statistics related to all types of works accomplished by the insurance companies. There are 27 insurance companies registered in Jordan.

Table 5 shows fire insurance premiums and insured paid compensations for the fire incidents that occurred during the period 2010 - 2014. It can be seen that the fire premiums are increasing every year, and as expected, the compensation payments are somehow fluctuating. In 2013-2014, the average premium payments and the average compensations payments has risen to about 33% and 17.3% of their figures in 2010-

2011, respectively. The high premium percentage may explain that the awareness for fire in all sectors especially, residential houses and the medium and small industrial firms have been increased significantly. Whereas, the increase in compensation percentage was moderate. This may be due to the high degree of safety measures applied.

TABLE V. FIRE INSURANCE PREMIUMS AND INSURED PAID COMPENSATIONS IN JORDAN (2010-2014)

	Years				
	2010	2011	2012	2013	2014
Premiums (Jor.Dinar)	56342885	57369056	60651004	68339553	69119571
Compensation (Jor.Dinar)	11234683	25569297	12534898	12750863	42142301

The records of JOIF shows that in 2014, the premium payments and the compensation payments for fire were 13% and 11.5% of the total premium and compensation amounts of all insured sectors, respectively.

Economic loss is high for incidents involving fires, some of the type of losses that can result from the accidents, injuries and fatalities are listed below. They may not apply altogether in every specific category, and also the costs of many losses are difficult to calculate accurately.

1. Payments for settlement of injury or death claims.
2. Payments for the recovery of damaged property and equipment.
3. Costs of fire suppressions.
4. Loss of function and operations income.
5. Increased insurance costs.

In Jordan, the ministry of labour which is the main reference for issuing laws related to the employer, employees and work place did not publish all the laws and regulations related to human safety.

Much can be done to reduce the probability of occurrence, but it is impossible to prevent all major fires. The effects of fire and smoke on life and property may be controlled by issuing legislative measures for the sources and types of fire. These measures realized in the forms of laws, codes and standards are combined with technological safety measures to achieve the highest degree of protection.

To improve the safety regulations and codes, it is important to determine the percentage of contribution of each category of the total number of fires during the period 2008-2014. Table 6 lists the percentage of contribution.

TABLE VI. THE PERCENTAGE OF CONTRIBUTION OF EACH CATEGORY (2008-2014)

Category	Number of occurrences during 2008-2014	Percentage of contribution
Wild land and farms	65101	49.7
Used tyres and solid waste	22853	17.5
Residential homes	16515	12.6
Motor vehicle and petroleum tankers	9567	7.3
Commercial and business places	4809	3.7
Industrial plants and storage places	3488	2.7
Transformers and power machines	3113	2.4
Others	5301	4.1
Total	130747	100%

The table illustrates that wild land and farms contributed to about 50% of the total number of fires occurred in the 2008-2014. This figure of contribution is higher than the figures obtained for used tyres and solid waste and residential homes by almost 65% and 75%, respectively.

By comparing these results with the results obtained previously [7], it can be seen that wild land and farms still holds the highest percentage of contribution, and its percentage in this study increased by only 4% of the results obtained in the past. Whereas the contribution of residential homes decreased by 32% of previous results.

Since the top three categories in the table, wild land and farms, used tyres and solid waste and residential homes accounts for 80% of all fire occurred in 2008-2014. It becomes important that the fire reports must include all types of information, which upon analysis will help the PFB engineers and researchers to make policy development and operational decisions. This is in addition to the general aim of other government departments in reducing the number of incidence of fire and related death, injury and property damage.

By comparing the figures of percentage of occurrence for wild land and farms reported in 2003 to that in 2013, it can be seen that the percentage of arson has risen to about 67%, whereas the percentage of children carelessness has decreased by about 61% for the 10 years period.

The most common objective for providing fire safety in controlled places such as residential homes, shopping malls, storage places and indoor industrial plants is to insure life safety and property protection. The national codes must give more emphasis and detailed execution on these two important issues. Many fire protection systems for example, automatic sprinklers, fire doors and a suitable escape path provide both life safety and property protection [6]. Detailed awareness on the economics and measures of fire safety are published in such References [10, 11]. The incidents occurred to these places may revive questions about the safety of materials used in buildings. It would be of value if a tag is attached to the decorating materials and textile fabrics containing the burning rate (fire speed) and volume of smoke that will be generated in

case of fire. This information may help the public in choosing the suitable material.

In Jordan, severe fires in large and tall buildings are not common. Globally, the two recent fire incidents were in the tallest residential buildings in Dubai in 2015 and reoccurred in 2017, and the other one in London in 2017. The two incidents produced many deaths and severe property damage. Understanding fire severity, fire resistance and the behavior of materials at elevated temperatures can produce buildings which can assist to reduce the risk of loss of life and property in the event of a fire.

Recently, Jordan has witnessed millions of refugees from neighboring countries. According to official Departments [12,13], that in 2017, the total population of Jordan is 9.5 million people, while the number of non-Jordanians who reside in the country is nearly 3 million, representing 30.6% of overall population. Jordan was named as the top refugee-hosting country, and it is not receiving enough support to deal with the outcome of the crisis.

Refugees have stressed economic and all types of infrastructure in Jordan, which was already suffering from different issues before the refugee crisis. They have had a major impact on many aspects of life in Jordan, some of these aspects are:

1. Housing, the increased demand for housing either in camps or in cities drove up refugees to live in houses which may lack the basic element of safety.

2. Water and power supply, there were a tremendous increase in consumption of water and power, which in any misuse may lead to an accident.

3. Roads, many refugees brought their vehicles along with them. This has stressed the traffic on the roads, which was already suffering from heavy traffic. This is in addition to the bad maintenance of the vehicles.

4. Environmental, all types of waste and storage have increased the potential of hazards.

5. Social and political, these two issues have resulted in arson and other wrongful acts which lead to hazards.

The above categories and their associated incidents contributed significantly to their correspondent categories shown in Table 2.

To show the significance of the above mentioned constraints on the selected categories in this study, a comparison between the numbers of incidents of the selected categories (Table2) obtained in 2008-2014 and that in 1996-2004 [7] are shown in Table 7. The table illustrates that the percentage of accidents have been extremely increased for all the categories. In specific, the total number of incidents occurred in 2008-2014 have risen to about 54% of the figure obtained in 1996-2004.

TABLE VII. COMPARISON OF ACCIDENTS BETWEEN (1996-2004) AND (2008-2014)

Category	Years		% increase
	1996-2004	2008-2014	
Wild land and farms	28663	65101	56
Used tyres and solid waste	6760	22853	70
Residential homes	11196	16515	32
Motor vehicles & petroleum tankers	5044	9567	47
Commercial and business places	1947	4809	60
Industrial plants and storage places	1812	3488	48
Transformers and power machines	-	3113	-
Others (miscellaneous)	4838	5301	9
Total	60260	130747	54

In general, education, awareness of fire consequences and conducting of drills (fighting small fires and evacuation) are important measures to enhance fire safety.

Some topics are not discussed in this paper such as sources of ignition, starting point of fire and many others. These topics might be of interest in other analysis.

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