Original Article

Measurements of PM2.5, PM1, PM10, VOCs and HCHOs During A Building Fire In Central Lahore and its Possible Effects on Mental Health

Shiraz Aslam, Sumira Qambar Bokhari, Nauman Mazhar, Qambar M. Bokhari, Shahid H. Warris and Ali Anjum

Objective: To measure the levels of various pollutants in a big fire in a building in Lahore.
Methods: A new specific measuring device was used to monitor the values during the fire and a week later at exactly the same spot and at the same time of the day.
Results: The values obtained of the PM2.5, PM1, PM10, volatile organic compounds and formaldehyde were markedly deranged. This was a warning sign for the fire men to wear proper protective gear on duty.
Conclusions: It is important to contain a building fire as soon as possible as it is a health hazard. It produces pollutants of various sorts such as the particulate matter of 2.5 to 10 micron sizes. It also produces volatile organic compounds and formaldehyde which can cause serious health problems from conjunctivitis and nasal irritation to cardiac arrhythmias anxiety, depression and cancer. It is equally important to make sure that the fire men are issued proper protective gear for fire fighting in addition to the mandatory professional training.
Keywords: fires, ecosystem, environmental, pollution, mental health anxiety depression.

Introduction

In August 2019, a large departmental store in the center of Lahore caught fire. The store had varied quantities and qualities of materials in it. This included textiles, foams, and in addition to that there were the structural materials themselves of the building including paint, wood, varnish, cardboard and MDF boards etc. Fire fighters almost took major part of the day to put out the fire. The major hallmark of a threatening fire, including heat, smoke and particulate matters were present. The fire fighters were very quick to arrive at the scene but were noted to be not adequately protected especially against smoke and particulate matters in the atmosphere. Fires can kill. Its smoke and toxic gases kill more people than flames do. The toxic gases thus released have the capacity to disorientate the person and cause drowsiness. Fires can kill by asphyxiation and their smoke is the main cause of death. Even delayed asphyxia can cause death.[1] Fire is lethal because of its carbon monoxide and cyanide fumes. These cyanide fumes are a result of combustion of many synthetic materials found commonly in ordinary homes such as plastics, rubbers and foams. Thus, synthetics polymers (teflon, nylon and polyester and polyethylene) are used in huge quantities in everyday house hold objects. In addition to these there are present other chemicals as well such as polyacrylonitrile, polyurethane and melamine but natural materials such as wool, horsehair, and silk. Paper is present in large quantities as well which aids the fire to burn more.[2] A by product of burning wool is hydrogen cyanide and on burning wood manganese and benzene are produced as by-products. These contain attached into their structure nitrogen and halogens as well. This is a lethal combination as when this burns in a fire, it produces hydrogen cyanide and inorganic acids. Humans inhale such deadly fumes which gives lethal levels of carboxyhemoglobin and cyanide in blood. The oxygen is used up as well and results in its depletion in the air as well later in the victim's blood. Thus, the fact that the combustion of certain household furnishings can produce cyanide has been proved by numerous studies. Thus cyanide poisoning results whose characteristics are hypoxia, metabolic acidosis and raised lactic acid levels. A fire will certainly give off heat but in a confined space of a room the temperatures can rises up to 1000 to 2100°F (5371160°C). Inside a room, there is a gradient of heat in the ascending order. At the feet it can be 100 degrees, rising quickly to 600 degrees at the level of the eyes and soaring up to 1500 degrees at the ceiling level. This is hot enough to burn the clothes and scald the skin, both sticking to each other like were never separate from each other. A person inhaling at this level will scald his respiratory tract up to the lungs with intense oedema. Although the name of a lethal gas like cyanide brings to mind instantaneous death, but in a fire the heat is a stronger role to play in human deaths.[3,4] Thus, Cyanide poisoning is not very frequent in fire fatalities, but when it is present it is associated with significant carboxyhemoglobinemia. An Australian study showed a correlation between

elevated blood ethanol and whole blood cyanide levels ($r = 0.36$, $p < 0.001$) and between elevated carboxyhaemoglobin and hydrogen cyanide levels. Thus, there is a strong association between an elevated carboxy- haemoglobin level and cyanide levels. Once cyanide poisoning sets in, it can damage the cardiac function as well, resulting in it to stop contracting altogether, causing a cardiac arrest and imminent death unless treated in time.[5] Building fires can also affect the mental health of people in general and also among the fire fighters. Studies have shown high levels of stress among the sufferers.[6] Therefore various researchers have recommended psychological interventions to promote the mental health and enhance the knowledge. Moreover training can improve behaviours which can result in better outcome.[7]

Methods

A new multi-pollutant measuring device (Life Basis DM106A) was used to measure the pollutant levels. The device was calibrated before every new set of readings were taken. A week after the fire episode, ordinary day readings were also taken at the equivalent hour on the clock coinciding with the midway point of the total duration of the fire. Both readings were recorded after the device was given 5 minutes in the vicinity of the fire. During taking both the readings the same spot was used which was about 12 meters from the building ablaze.The readings were plotted in the table.

Results

It is evident from **(Table-1)**. That there is a stark difference between the concentrations of the particulate matters of all sizes (PM2.5, PM1, and PM10) during the blaze and a week after. In addition to these the concentration of the volatile organic compounds (VOC) is also increased and so is the level of formaldehyde (HCHO). It is show below why the concentration of these particulate matters and the other chemicals increases as the material they are a constituent of start to combust. The PM2.5 was so huge in concentration at the time of the fire that its concentration went beyond the scale of the device. The humidity went up as well despite the fire, because of the sheer amount of water the fire hoses were churning out.

Discussion

Smoke, is defined by The American society of Testing and materials as "the airborne solid and liquid particulates and fire gases evolved when a material undergoes pyrolysis or combustion". If smoke is inhaled, this causes injury to the upper and the lower respiratory tract. There is supraglottic thermal injury, chemical irritation of the respiratory tract, systemic toxicity caused by cyanide and carbon monoxide. Once the respiratory tract is damaged by the heat, the cilia and the surface epithelium is disrupted and inflammation ensues. The lower tract especially is unable to clear the debris and stagnation leads to poor ventilator effort and infections leading to pneumonia and acute respiratory distress syndrome. The patient is unable to breathe and keep up the oxygenation which necessitates artificial ventilator support. Particulate matters can be either in the liquid or the solid forms. They can be naturally occurring or manmade as well. They originate from duct, ash or soot especially during combustion of solids, liquids. Car engines are also a big source of particulate matter. A high concentration of particulate matters, such as the PM2.5 and PM10 is already a problem in most developing cities of the world and is the same in Lahore. It is reported that fires 'significantly' elevate their concentrations. PM2.5 is 2.5 micrometer in diameter and are the 'fine' particles because they are so small (2.5 micrometers is one 400th of a millimeter) that they can enter the deepest parts of the lungs and cause serious problems. Fine particulates are main cause of reduced visibility and 'haze' so commonly seen over Lahore. Human sources of these are more important than natural sources as these can cause systemic inflammatory and oxidative stress responses as seen in large polluted cities like in China.[8] It is seen that the synthetic materials will give rise to 12.5X more

Table-1: Measurements at the same spot during the blaze and a week after the fire. Recommendations for a safe level are included. The air quality index is colour coded and the indication on the fire day was at the maximum in the classification-' Very Unhealthy'(purple). This is equal to the score of 201-300. (https://webcam.srs.fs.fed.us/test/AQI.shtml)

	PM2.5 µg/m³	PM 1 µg/m³	PM 10 µg/m³	TVOC mg/m3	HCHO mg/m3	Humidity %	AQI colour indication
Ordinary days	59	36	71	0.45	0.17	64	Moderate
Fire	9.999	61.8	1444	2.4	0.3	73	Very Unhealthy
Recommendation	25 (WHO)	Not set yet	50 (WHO)	0.26(Japan)	0.12(Netherland)		

particles per mass as compared to natural materials like wood.[9] It is reported, not too surprisingly that the PM2.5 levels were significantly higher during a wildfire episode. A rise in Pm2.5 during a fire can lead to serious heart ailments. It has been reported that a certain increase in PM2.5 concentration in the atmosphere was associated with an increase in ischemic heart disease admissions (by 1.86%) in the hospitals. The researchers in the USA further tried to ascertain the reasons how the PM2.5 can lead to adverse cardiac events. They found out that the PM2.5 can lead to systemic pulmonary inflammation and increased release of various cytokines. They also reported that when these particulates get into the blood stream, being so fine in size, they can cause vascular events such as thrombus formation, increase in blood viscosity, disruption of the plaque and cardiovascular adverse events. Finally, these researchers also highlighted that these fine particulate matters can cause irregular or increased heart rates which can lead to cardiac arrest. Particulate matter causes a lot of health related problems such as asthma (3% increases for each10 µg/m3 rise in PM10) and others which necessitates increased (2%) hospital admissions. It is noted that the particulate matters which are in the 'ultrafine size range' can have 'surface transition metals' which can give rise to injurious oxidants with 'enhanced toxicity'.[10,11] The lungs thus take the main brunt of the particulate onslaught where these chemical can 'catalyze' an 'oxidative stress reaction' in the pulmonary tissue causing wide spread tissue damage. This was confirmed by alveolar lavage which confirmed that the inflamed lung tissue enhanced the 'metal-mediated oxidation' causing cardiopulmonary damage. The pulmonary damage by PM.5 and PM10, after fires can be significantly toxic to the alveolar macrophages. This has also been confirmed by another study which confirms the fact that the PM10 particulate matters are particularly more toxic (four times as much) to the macrophages in a fire than from exposure to ordinary urban pollution particulates. Out of 20,000 premature deaths in the USA, many were soot related due to sulphur dioxide and nitrogen oxide which combine to give acid rain. A Polish study confirmed soot in 80% of the fire victims in their airways. About 60% had inhaled enough carbon monoxide to be a reason for death.[12] Synthetic materials in the house tend to produce more smoke such as styrene used in disposable plates and glasses, insulation material in electronic appliances, toys and tires. Vinyl polymers like PVC pipes, plastic chairs and tables produce increased amounts of thick smoke. Toxins which are present on a long term basis including volatile organic compounds and formaldehyde with the particulate matter can result in thousands of deaths.[13] The smoke can contain heavy metals such as arsenic, cobalt, chromium, lead, and mercury. PM2.5 can damage the eyes as well resulting in ocular cell autophagy, and it is also reported that the Pm2.5 can damage the DNA in the corneal cells.[14,15] After tackling a fire the firefighters were reported to have a deposit of volatile organic compounds. There are numerous reports where the researchers have associations between cancers affecting the fire man after a career in fire fighting. There is evidence of DNA damage and epigenetic changes in specific gene promoters. Some mention the increased incidence of mesotheliomas, lung, leukaemia, prostate, brain, and haemopoietic malignancies.[16,17]

In the USA it is noted that certain cancer types have an increased association in fire fighters as compared to the general public. A few are enlisted below.[18]

Testicular Cancer	2.02 Times Greater Risk
Multiple Myeloma	1.53 Times Greater Risk
Non-Hodgkin's Lymphoma	1.51 Times Greater Risk
Skin Cancer	1.39 Times Greater Risk
Prostate Cancer*	1.28 Times Greater Risk
Malignant Melanoma	1.31 Times Greater Risk
Brain Cancer	1.31 Times Greater Risk
Colon Cancer	1.21 Times Greater Risk
Leukemia	1.14 Times Greater Risk

Higher rates of anxiety and depression were noted among people who suffered from wildfire at Alberta. These effects were more pronounced immediately after the episode. [19] This not only affects general population but also the personnel who are involved in fire fighting. This is the reason that mental health improvement plans have been devised to decrease mental stress and other negative consequences. This will result in overall improvement of mental health. [20]

Conclusion

It is important to contain a building fire as soon as possible as it is a health hazard. It produces pollutants of various sorts such as the particulate matter of 2.5 to 10 micron sizes. It also produces volatile organic compounds and formaldehyde which can cause serious health problems from conjunctivitis and nasal irritation to cardiac arrhythmias and cancer. It is equally important to make sure that the fire men are issued proper protective gear for fire fighting in addition to the mandatory professional training.

Department of Psychiatry
SIMS/SHL Lahore

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