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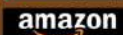
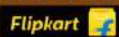
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Toxicological impact of Fireworks on Environment and Human Health

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Preface

Customary firework burning during Diwali in India, Chinese Spring Festival, Independence Day in the USA, Lantern festival in Taiwan, and Guy Fawkes in the UK is reported. Firework burning causes short-term variations in air quality and the release of several hazardous chemicals into the air. Short-term exposure to particulate matter, gaseous pollutants and several metals can result due to the bursting of firecrackers and could pose serious health risks. Several types of research have also revealed the emission of organic pollutants during fireworks. Pollutants released from fireworks at high altitudes are diluted before coming into contact with human populations, which can reduce health impacts. However, ground-level firework display has an immediate effect on human health. Acute eosinophilic pneumonia has been reported due to inhalation of smoke, whereas fever, cough and dyspnoea are caused by acute effects.

This authored book elaborates on the chemistry of fireworks, and how their burning impacts the environment (flora and fauna) and human health. The book presents in-depth chapters on relevant issues associated with firework burning and also presents findings of interesting computational and experimental case-studies showing how the air quality is hampered by firework burning and what specific health issues are faced by the exposed people upon exposure to smoke and other hazardous pollutants emitted by the fireworks. Through this book, the authors aim at creating

awareness and better understanding associated with firework burning hazards.

The book may be of interest to readers belonging to different academic backgrounds. The book would also be useful for students pursuing post-graduation and research scholars who are pursuing a Ph.D. in Medicinal or Environmental Chemistry. Higher Educational institutions like colleges and universities can be a part of readership as the students and faculty members can put the data of the book to use in writing reports and assignments.

Tahmeena Khan

Saima Arif

Nikita Tiwari

Alfred J. Lawrence

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CHAPTER-1

CHEMISTRY OF FIRECRACKERS

Abstract

Fireworks are often used across the world and can result in serious air pollution in a short amount of time. The use of chemistry that appeals to the public most is undoubtedly fireworks. However, pyrotechnic activities like fireworks pollute the environment and endanger the health of both plants and animals. Colours are produced by various metal complexes. Sodium (Na) salts, for instance, produce yellow or orange, copper (Cu) and barium (Ba) salts produce green or blue, and calcium (Ca) or strontium (Sr) salts produce red. These metals, when breathed or swallowed, can have a wide range of short- and long-term consequences, including renal disease, cardiotoxic effects, and various cancers. These reactions can include vomiting, diarrhoea, or asthma attacks. In this chapter, we have discussed the chemistry of firecrackers and their toxicological impacts on humans and plants.

Keywords: Firecrackers, fireworks, pyrotechnic, toxicological impact

1. Introduction

It is a global tradition to celebrate major events by igniting firecrackers. Fireworks, often known as pyrotechnics, are an

CHAPTER-2

ENVIRONMENTAL AND HEALTH HAZARDS

OF FIREWORKS

Abstract

Pollutants released by fireworks can significantly reduce air quality and harm human health. To contribute to the introduction of comprehensive monitoring and effective legislation to reduce the short-term effects of fireworks, we reviewed the results of previous studies on the effects of fireworks. These studies mainly focused on chemical composition (water-soluble ions, elements, carbon materials, organic matter, and trace gases) as well as related human health effects during pyrotechnics. The studies showed pyrotechnic particle concentrations 1-5 fold higher than their respective background levels. The health effects of particulate and gaseous pollutants, including metals emitted from fireworks, require further epidemiological investigations to prevent health problems and treat patients. The fireworks industry needs innovation to reduce pollutant emissions.

Keywords: fireworks, pyrotechnics, carbon materials, epidemiological investigations, short-term effects, innovation.

1. Introduction

Today, fireworks mark celebrations all over the world. From ancient China to the New World, fireworks have evolved

CHAPTER-3

AIR QUALITY VARIATION DUE TO FIREWORKS DURING PROMINENT FESTIVALS: SOME CASE STUDIES

Abstract

The rise in air pollution is a matter of global concern. Although much attention has been given to mobile sources of pollutants, periodic events like a firework display and related disruptions in air quality are often neglected. The pollutants emitted from fireworks cause short-term hikes in pollutants concentration and impact human health. This chapter presents some case studies reporting the impact of the customary fireworks display during some of the prominent festivals viz. Lantern festival, Chinese Spring New Year and Diwali on air quality. Significant health risks due to emissions from fireworks are also reported which calls for urgent attention and policy implementation.

Keywords: Fireworks, case studies, health impact, policy

1. Introduction

Customary fireworks burning has been a part of many festivals as a ritual. Be it new year's eve celebrations [1], The Las Fallas in Spain [2], The Lantern Festival in China, Bonfire Night in the UK, Tihar in Nepal, Day of Ashura in Morocco, Sky fest in

CHAPTER-4

MOLECULAR DOCKING STUDIES OF POTENT POLLUTANTS EMITTED FROM FIREWORKS

Abstract

Pollutants released from fireworks at high altitude are diluted before coming into contact with human populations, which can reduce health impacts. However, ground level firework display has an immediate effect on human health. Customary firework burning during different festivals and occasions has been reported from different parts of the world. A virtual study was performed to assess the extent of binding of sixteen important components of fireworks including Al_2O_3 , $\text{Ba}(\text{NO}_3)_2$, C_6H_6 , CO , Ethylbenzene (C_8H_{10}), $\text{Fe}_2\text{O}_3 \cdot \text{H}_2\text{O}$, KClO_3 , KClO_4 , KNO_3 , $\text{Na}_2\text{C}_2\text{O}_4$, NH_3 , NO , o-Xylene (C_8H_{10}), SO_2 , $\text{Sr}(\text{NO}_3)_2$ and Toluene (C_7H_8) with human C-reactive protein (CRP), pepsin, and estrogen related receptor alpha (ERR alpha) protein. AutoDock 4.2.6 was employed to perform rigid docking. Against CRP, NH_3 exhibited the least binding energy viz. -5.58 kcal/mol. Against ERR-alpha, Al_2O_3 showed the least binding energy viz. -4.62 kcal/mol. Against pepsin, NH_3 showed the least binding energy (-5.49 kcal/mol). The results can be further elaborated and may guide future researches for the intervention of protein targets for chemical toxins.

Keywords: Air pollution, health, hazard, virtual screening, protein

CONCLUSION

The potential adverse impacts due to short-term anthropogenic pollution caused by fireworks display are well understood. However a limited number of studies have been undertaken to comprehend the exact impact of fireworks on air quality and human health in particular. India and China are the two countries from where the majority of studies are being reported. The reported literature reveals high particulate fraction in fireworks which is also associated with several elements like barium (Ba), lead (Pb), potassium (K) and strontium (Sr) etc. There are also evidences of ozone formation, formation of nitrous acid but more research is needed to fully understand the chemistry and chemical modifications of fireworks.

Another important aspect is the effect of fireworks on human health which needs more deliberation. Nevertheless, it is known that the short-term exposure to fireworks may lead to exacerbation of respiratory illnesses including asthma. A major limitation in the complete understanding of effects related to fireworks burning is the transient nature of the fireworks' events which last only for a few hours to days. Owing to this, usually the sample size is limited rendering it difficult to compare results. The dispersion of pollutants is also influenced by the meteorological conditions needing thorough exploration as fireworks events fall in different seasons. Consistency in field measurements during the firework

events must be practiced. The monitoring/measurement must also cover the pre and post firework period. The meteorological data must also be collected simultaneously for the monitoring period. Other than the $PM_{2.5}$ and PM_{10} fractions the PM data should be speciated to know the chemical composition of the particulate matter as very few studies have reported the particle mass and number size distributions. Global satellite measurements must also be utilized to understand spatial and temporal variations in pollutant concentrations related to fireworks events. Ancillary data such as fireworks sales can also be of use. Characterization of health effects associated with acute exposure to pollutants emitted by fireworks must be studied in depth. Daily hospital visits and mortality figures should be analysed to understand the short-term health effects related to fireworks emissions. The impact of policy implementation, if functional could help in understanding the impact of the policy on air quality during fireworks events.

