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ASSESSMENT, ANALYSIS AND DISPOSAL OF BURNT FIRECRACKER RESIDUE

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Abstract:

This study was conducted during the Diwali festival period in November 2021 at a residential site in Bhopal, Madhya Pradesh, India. The study concludes that the residue from burnt firecrackers adversely affects the environment and ecosystem if proper segregation is not implemented. While most of the carbon and sulfur in gunpowder is consumed when a firework is set off, the remaining residue contains chemicals that can be harmful to the environment. Therefore, segregating burnt firecracker residue after use is essential. This study aims to assess the effects of burnt firecracker residue on human health and the environment. Proper management and segregation of burnt firecrackers are essential to mitigate any adverse consequences for our well-being and the surrounding ecosystem.

Keywords: Firecracker; residue; hazardous; TSDF

1. INTRODUCTION

India is a major producer of firecrackers, primarily for domestic consumption. It is reported that nearly 85-90% of the nation's firecrackers are sold during the Diwali festival month. The widespread use of fireworks globally, often characterized by loud and brightly colored displays, generates substantial amounts of pollutant-filled residue. The large volume of fireworks used over short periods can release significant pollutants into the surrounding atmosphere, potentially causing severe health impacts. These pollutants, including primary aerosols, black carbon, sulfur dioxide, and carbon monoxide, can lead to cardiovascular problems, asthma, hypertension, bronchitis, and other ailments. These adverse effects on air quality have been reported in urban, rural, and suburban areas across the nation. Fireworks often contain heavy metals, gunpowder smoke, and solid residues. Consumer fireworks, in particular, leave behind a considerable amount of solid debris. Therefore, it is essential to assess the effects of firework usage on air quality in specific regions. [Carlos D. H. et al. 2020, Chi-Chi Lin, 2016, Hickey C. et al., 2020 & Garg A. and Gupta N. C., 2020].

The extensive use of fireworks worldwide is often accompanied by loud and brightly colored displays of fireworks and after burning generates large amounts of residue filled with pollutants. [Dangi B. and Bhise A., 2020 & Ghei D. and Sane R., 2018]. The huge amount of fireworks during short periods generates extensive amounts of pollutants in the surrounding atmosphere could result in severe health impacts. [Tandon R. et al., 2019 and Yerramsetti V. S. et al., 2013].

The heavy use of firecrackers releases toxic pollutants like primary aerosols, black carbon, sulfur dioxide, carbon monoxide, and many others which pollute the air and cause serious ailments like cardiovascular problems asthma, hypertension bronchitis, etc. [Bateman P.W. et al., 2023]. These adverse effects on air quality have been reported not only for large urban areas but also for the rural and suburban areas of the entire nation [Singh A.K. & Srivastava A., 2020, Katoria D. et al., 2013, Govindaraj V. et al., 2019]. Fireworks often contain heavy metals, gunpowder smoke, and solid residues. However, most consumer fireworks leave behind a considerable amount of solid debris from burnt firecrackers. [Kumar J. et al., 2021, Yifan Q. et al., 2023, Sweta Sinha and Kavita Goyal, 2021]. Therefore, it is essential to assess the effects of this celebration on air quality in the specific region.

This research investigated the residues from burnt firecrackers collected from various residential areas of Bhopal city following the Diwali festival in 2021. Composite sampling was conducted in Nehru Nagar, Arera Colony, Kolar Road, Bairagarh, and Peergate. The study highlights that fireworks leave substantial solid debris and that without proper segregation, this residue can significantly impact air quality. Furthermore, the research aimed to understand the broader environmental health effects of firecracker residues, noting that firecrackers contribute to air pollution and negatively affect human well-being, potentially exacerbating existing health conditions.

I. MATERIALS & METHODOLOGY

Study Area

In this study, residues from burnt firecrackers were collected through composite sampling in various residential areas of Bhopal city, including Nehru Nagar, Arera Colony, Kolar Road, Bairagarh, and Peergate. The samples were tested for key parameters, including physicochemical properties, total metal content, TCLP (Toxicity Characteristic Leaching Procedure), and WLT (Waste Leaching Test), to assess the impact of the burnt firecrackers. Subsequently, all samples were analyzed at the Treatment, Storage, and Disposal Facility (TSDF) in Pithampur, Dhar, Madhya Pradesh. The test results are summarized in Table 1.

Table-1: Analysis of Parameters Related to Burnt Firecracker Residue from Various Locations in Bhopal City

Physicochemical Parameters							
S. No.	**Parameter & Unit**	**Method of Analysis**	**Location of Sample Collection –Bhopal**				
			Nehru Nagar	**Arera Colony**	**Kolar Road**	**Bairagarh**	**Peergate**
1.	Physical State	-	Solid	Solid	Solid	Solid	Solid
2.	Colour	-	Multicolour	Multicolour	Multicolour	Multicolour	Multicolour
3.	Texture	-	Solid Dry	Solid Dry	Solid Dry	Solid Dry	Solid Dry
4.	Flash Point (^{0}C)	USEPA 1998, SW-846; 1020 A	>60	>60	>60	>60	>60
5.	Paint Filter Liquid Test (PFLT)	USEPA 1998, SW-846; 9095 A	Pass	Pass	Pass	Pass	Pass
6.	Bulk Density (g/cc)	APHA 23rd Edition; 2710 F	0.45	0.39	0.41	0.48	0.47
7.	Calorific Value With Paper (cal/g)	IS:1350 Part II – 1970	3654.23	3215.46	3785.14	3516.22	3312.85
8.	Calorific Value Without Paper (cal/g)	IS:1350 Part II – 1970	1075.66	923.41	1172.41	988.41	1001.71
9.	Loss on Drying @ 105 ^{0}C (%)	APHA 23rd Edition, 2017; 2540 B	4.25	4.86	3.51	3.99	4.35
10.	Loss on Ignition @ 550^{0}C With Paper (%)	APHA 23rd Edition, 2017; 2540 E	65.49	53.66	75.54	61.32	58.64
11.	Loss on Ignition @ 550^{0}C without Paper (%)	APHA 23rd Edition, 2017; 2540 E	33.62	31.29	35.86	34.55	33.66
12.	pH (At Room Temperature)	USEPA 1998, SW-846; 9045 C	10.92	10.91	10.89	10.88	10.92

13.	Sulphate as SO_4^{--} (mg/kg)	APHA 23rd Edition; 4500 SO_4^{--} - E	7.84	4.17	7.70	7.80	7.86
14.	Chloride as Cl^- (mg/kg)	USEPA 1998, SW-846; 9253	102.8	130.5	152.51	102.55	103.0
15.	Phosphate as PO_4^- (mg/kg)	APHA 23rd Edition; 4500 PO_4^{--} - D	3.38	5.68	4.13	5.21	7.25
16.	Cyanide (WLT) Spot test	USEPA 1998, SW-846; 9014	Absent	Absent	Absent	Absent	Absent
17.	Cyanide (TCLP) Spot test	APHA 23rd Edition; 4500-CN^- C&D	Absent	Absent	Absent	Absent	Absent
18.	Sulphide (TCLP) Spot Test	APHA 23rd Edition 2017, 4500-S^{2-} F	Absent	Absent	Absent	Absent	Absent
19.	Ammonia (WLT) (mg/L)	APHA 23rd Edition; 4500-NH3-B&C	169.96	169.4	175.2	145.6	166.8
20.	Ammonia (TCLP) (mg/L)	APHA 23rd Edition; 4500-NH3-B&C	1.12	0.84	1.4	0.84	1.68
21.	Carbon With Paper (%)	CHNS Analyzer	41.23	40.52	39.88	40.08	41.05
22.	Carbon Without Paper (%)	CHNS Analyzer	1.24	0.96	1.26	0.95	0.98
23.	Hydrogen (%)	CHNS Analyzer	0.46	0.22	0.95	1.19	0.65
24.	Nitrogen (%)	CHNS Analyzer	3.95	3.45	3.86	4.02	3.75
25.	Sulphur (%)	CHNS Analyzer	1.15	0.68	0.69	2.29	0.46

Total Metal							
S. No.	**Parameter & Unit**	**Method of Analysis**	**Location of Sample Collection –Bhopal**				
			Nehru Nagar	**Arera Colony**	**Kolar Road**	**Bairagarh**	**Peergate**
26.	Mercury as Hg-Total (mg/kg)	USEPA 1998 SW-846; 7471B	6.99	5.99	5.0	5.99	0.69
27.	Arsenic as As-Total (mg/kg)	USEPA 1998 SW-846; 7061A	5.0	4.0	5.0	4.0	3.0
28.	Cobalt as Co- Total (mg/kg)	USEPA 1998, SW-846; 7200	3.32	17.81	28.5	20.93	23.53
29.	Copper as Cu-Total (mg/kg)	USEPA 1998, SW-846; 7210	99.7	159.17	47.51	265	137.75
30.	Total Chromium as Cr- Total (mg/kg)	USEPA 1998, SW-846; 7190	585.48	308.4	141.53	251.53	409.41
31.	Iron as Fe- Total (mg/kg)	USEPA 1998, SW-846; 7380	5776.56	9311.58	1256.93	2685.95	6466.42
32.	Lead as Pb- Total (mg/kg)	USEPA 1998, SW-846; 7420	75.26	200.96	110.85	98.81	40.18
33.	Manganese as Mn –Total (mg/kg)	USEPA 1998, SW-846; 7460	151.5	271.59	128.6	268.6	275.49
34.	Nickel as Ni- Total (mg/kg)	USEPA 1998, SW-846; 7520	47.89	57.7	211.8	54.8	51.08
35.	Zinc as Zn- Total (mg/kg)	USEPA 1998, SW-846; 7950	83.28	30.84	62.45	53	106.18
36.	Cadmium as Cd- Total (mg/kg)	USEPA 1998, SW-846; 7130	1.27	97.49	4.35	2.07	3.06
Toxicity Characteristic Leaching Procedure (TCLP)							

37.	Mercury as Hg-TCLP (mg/L)	(USEPA1311), APHA 3112 B	0.03	0.04	0.05	0.03	0.03
38.	Arsenic as As-TCLP (mg/L)	(USEPA1311), APHA 3111 B	0.05	0.06	0.04	0.03	0.04
39.	Cobalt as Co- TCLP (mg/L)	(USEPA1311), APHA 3111 B	0.29	0.28	0.32	0.72	0.27
40.	Total Chromium as Cr- TCLP (mg/L)	(USEPA1311), APHA 3111 B	1.18	1.43	2.25	1.88	1.28
41.	Copper as Cu- TCLP (mg/L)	(USEPA1311), APHA 3111 B	0.47	0.48	0.39	0.63	0.57
42.	Iron as Fe-TCLP (mg/L)	(USEPA1311), APHA 3111 B	20.07	10.79	40.05	30.02	13.7
43.	Lead as Pb- TCLP (mg/L)	(USEPA1311), APHA 3111 B	1.0	1.12	1.36	1.0	1.09
44.	Manganese as Mn –TCLP (mg/L)	(USEPA1311), APHA 3111 B	3.06	6.63	3.39	5.08	3.4
45.	Nickel as Ni- TCLP (mg/L)	(USEPA1311), APHA 3111 B	0.36	2.41	0.24	0.53	0.55
46.	Zinc as Zn- TCLP (mg/L)	(USEPA1311), APHA 3111 B	0.46	0.63	0.93	1.1	0.47
47.	Cadmium as Cd-TCLP (mg/L)	(USEPA1311), APHA 3111 B	0.05	0.05	0.04	0.04	0.05

Waste Leaching Test (WLT)

S. No.	Parameter & Unit	Method of Analysis	Location of Sample Collection –Bhopal				
			Nehru Nagar	Arera Colony	Kolar Road	Bairagarh	Peergate
48.	Mercury as Hg-WLT (mg/L)	APHA 23rd Edition 2017, 3112 B	0.02	0.02	0.03	0.01	0.01
49.	Arsenic as As-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	0.01	0.02	0.02	0.01	0.01
50.	Cobalt as Co-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	0.15	0.24	0.22	0.26	0.2
51.	Copper as Cu-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	0.45	0.18	0.73	0.35	0.17

52.	Total Chromium as Cr-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	1.12	1.18	0.96	1.14	1.19
53.	Iron as Fe-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	10.16	10.27	23.9	20.99	2.25
54.	Lead as Pb-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	0.77	0.87	0.83	0.96	0.96
55.	Manganese as Mn-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	0.47	1.13	0.81	1.34	0.71
56.	Nickel as Ni-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	0.34	0.35	0.04	0.38	0.29
57.	Zinc as Zn-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	0.35	0.34	0.72	0.6	0.42
58.	Cadmium as Cd-WLT (mg/L)	APHA 23rd Edition 2017, 3111 B	0.03	0.04	0.03	0.03	0.04

II. REULTS & DISCUSSION

The analysis results for key parameters, including physicochemical properties, total metal content, Toxicity Characteristic Leaching Procedure (TCLP), and the Waste Leaching Test (WLT), are detailed in Table 1.
The burnt residue from all five locations showed the presence of total metal content, as well as substances identified in the TCLP (Toxicity Characteristic Leaching Procedure) and WLT (Water Leach Test). These findings indicate that the residue is hazardous and could have harmful effects on both humans and the environment.
The burnt firecracker residue possesses toxic, reactive, and flammable properties, necessitating careful handling and disposal to mitigate adverse effects on human health and the environment.

III.CONCLUSION:

The remnants of burnt fireworks contain harmful chemicals, necessitating their proper disposal at a Treatment, Storage, and Disposal Facility (TSDF). Fireworks pose not only a fire risk but also harm the environment by releasing hazardous substances into the air. To ensure safety, it is crucial to handle and dispose of fireworks with care, as their chemical composition can ignite fires and endanger waste collection personnel. All fireworks, whether used or unused, should be treated as non-recyclable waste. Do not place any part of fireworks in regular trash bins or containers.
The following key steps are required for responsible disposal:

- **Segregation:** The residue of burnt firecrackers must be separated from other waste materials and collected in a designated bag or container.
- **Avoid Overbuying:** Purchase only the quantity of fireworks intended for use, as both used and unused fireworks are not recyclable.
- **Guidelines:** Specific guidelines for handling and disposing of burnt firecracker residue need to be developed to ensure safe practices.

Recommendations:

- Burnt firecracker residue should be collected separately and transported to a Treatment Storage and Disposal Facility (TSDF).
- This residue must be incinerated in the incinerator of a TSDF.
- The ash produced from this incineration process should undergo stabilization before being disposed of in the Secured Landfill (SLF) of the TSDF.

Studies conclude that proper disposal practices not only protect the environment but also ensure the safety of individuals involved in waste management.

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