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Assessment of the Impact of Fireworks on Ambient Air Quality

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Abstract*—Fireworks are one of the most unusual sources of pollution in atmosphere; although transient, these pollution episodes are responsible for high concentrations of pollutants. The festival of Diwali is celebrated all over India with extensive coordinated fireworks display. The influence of these celebrations on the immediate and long-term air quality and impact on the health and well being of the public needs research. Atmospheric pollutants emitted during fireworks display, have significant effects on human health and environment, on the eve of Diwali festival when extensive fireworks are burnt. The combustion clouds contain harmful fumes and particulate matter released at the surface. Particulate matter is one of the major concerns, with PM_{10} and $PM_{2.5}$ being especially hazardous. Existing emission standards impose restrictions on the total mass concentration of emitted particulates, PM_{10} and $PM_{2.5}$. This study is focused on the influence of fireworks on the ambient air quality at Dhanbad, India, during Diwali in October 2014. Particulate matter samples are collected during the period of three days, on the day of Diwali and also on the day before and the day after. Elevated concentrations of particulates PM_{10} and $PM_{2.5}$ were measured during the intense usage of fireworks. The concentration of PM_{10} was observed to increase to about four fold over the control days of observation during the period. Moreover, the concentration of $PM_{2.5}$ increased by 200%. The fireworks activities have been increasing every year and generation of particulates at their increased levels for short duration can potentially cause adverse health impacts on a regional scale in a highly populated region.
Keywords*—Fireworks; Particulates; Air Quality

I. INTRODUCTION

Urban outdoor air pollution is estimated to cause 2 million deaths throughout the world every year (World Health Organization) and have been related to a variety of harmful health effects. Air pollution is an emerging issue in the city of Dhanbad, one of the most populous city of Jharkhand and second largest urban agglomeration in the state.

Fireworks are truly unique sources of atmospheric pollution that generate massive quantities of pollutants within a short span of time. They are generally associated with festivities worldwide, such as New Year's Eve celebrations, the Las Fallas in Spain, the Lantern Festival in China, Bonfire Night in UK, the 4th of July celebrations in US and Diwali festival in India. These events involve extensive use of pyrotechnics on a regional, and often, national scale.

In recent times, short-term air quality degradation episodes are drawing increased attention of the scientific community as they considerably affect human health through long-term adverse effects. This provides scientists with a unique opportunity to study short-term degradation of air quality and its likely human health impacts. Burning of fireworks during festivals are significant contributors to air pollution in India, which are of increasing concern in terms of health hazards and effects on environment. Diwali festival experiences the most extensive burning of fireworks in India causing a major concern for environmental and atmospheric pollutants such as, particulate matters (PM_{10} and $PM_{2.5}$) which are released in significant quantity, associated with serious health hazards. Particulate Matters (PM_{10} and $PM_{2.5}$) are an air pollutant that causes major environmental problems and has a disproportionately harmful impact on human cardiovascular and respiratory systems.

Air aerosol is the main factor for the pollution of atmosphere and has caused many environmental problems, such as impact on human health, visibility, and climate changes. Especially, inhalable particulate (PM_{10}) is directly related to human health, which can exist stably in the atmosphere for a long time, penetrate indoors easily and even get deep into the lungs and some may even get into the bloodstream (US EPA, 2003). So, PM_{10} has been widely studied to assess and regulate air quality. And recently much attention has been paid to the table 1.

National Ambient Air Quality Standards (NAAQS), by CPCB, India.

Atmospheric Pollutants	National Ambient Air Quality Standards (µg/m3)
PM_{10}	**100**
$PM_{2.5}$	**60**

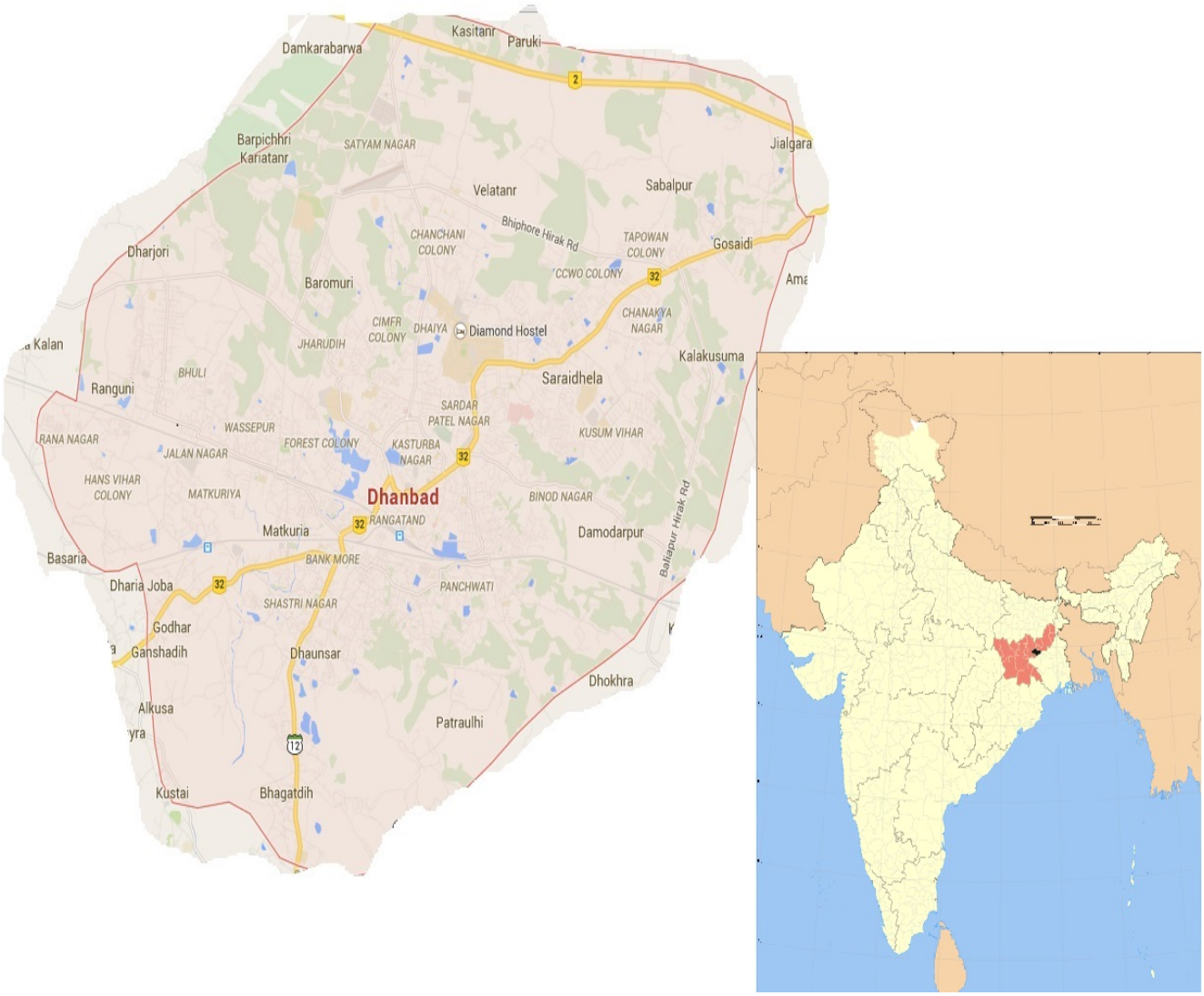

Fig.1. Political map of India, the zoomed portion is shown outside the map presenting the schematic layout of Dhanbad

effect of PM on human health, following some epidemiological studies with different pollutant levels, because its chemical composition directly affected its physicochemical property. A number of publications have appeared describing the environmental and health impact of firework smoke. It is not unreasonable to expect that the burning of fireworks on Diwali season could be exerting a significant impact on the local air quality and also possibly the health of the population. The objective of this work was to establish whether the concentrations of $PM_{10}$and $PM_{2.5}$ in ambient air in Dhanbad are effected measurably by fireworks emissions. Sampling was performed continuously during the period of three days in October 2014 and the contents of PM_{10} and $PM_{2.5}$ were determined.

II. EXPERIMENTAL METHODOLOGY

A. Area description and Sampling Site

Dhanbad is the most densely populated city in the state, affected by increasing air pollution level as a result of concentrated industrial activities and urbanization. Dhanbad is an industrial city and one of the busiest commercial centres in India. It is famous for its coal mining and has some of the largest mine reserves in India and is also known as Coal Capital of India. It lies between 23.8^{o} North latitude and 86.45^{o} East longitude. A schematic layout of Dhanbad is shown in Fig. 1.The land area of Dhanbad District is about 2000 km^{2} with an average population density of around 1000 per square kilometer. Dhanbad being one of the highly populated regions in Jharkhand, any significant change in the air quality can induce dramatic influence in the social picture for this region. The daily vehicular emissions results in the increase of atmospheric pollution with heavy particulate-loading. Diwali is celebrated in Dhanbad along with rest of India with great enthusiasm. Huge amount of crackers and sparklers are burnt mainly on the day of festival (Diwali day) and also on the day before and the day after. The selected study location includes one of the busiest roads in Dhanbad with vehicles moving around all the time, which are considered to be the major traffic intersection in the city and exhibit intense human activity. The impact of firecrackers on the air quality over Dhanbad district in Jharkhand was carried out. We focused on changes in the PM_{10} and $PM_{2.5}$ concentration levels in the atmosphere during the fireworks associated with Diwali festival on October 22nd, 23rd and 24th, 2014.

B. Sampling

In the present study Particulate matter samples are collected for twenty four hours with the starting time 00:00 am to 11:00 pm during Diwali, the day before and the day after.

In this method, high volume pump is situated in an appropriate location preferably a little bit higher from the ground level (5 m). The flow rate of pump would be adjusted, considering the location of pollutants dispersion in the environment. A fiber glass filter is placed in the filter holder and sampling is done. Filters before being used, are kept for 24 h in silica gel desiccators to equilibrate to the temperature and relative humidity held at constant values. Thereafter, the filters are weighted using an exact scale. After sampling, the moistures of filters are absorbed again, the differences between the filter's weights before and after the sampling are measured and also the amounts of particulates per volume unit are measured and the contents of PM_{10} and $PM_{2.5}$ are determined. The existing mass concentrations of PM_{10} and $PM_{2.5}$ are then compared with the EPA established National Ambient Air Quality Standards (NAAQS).

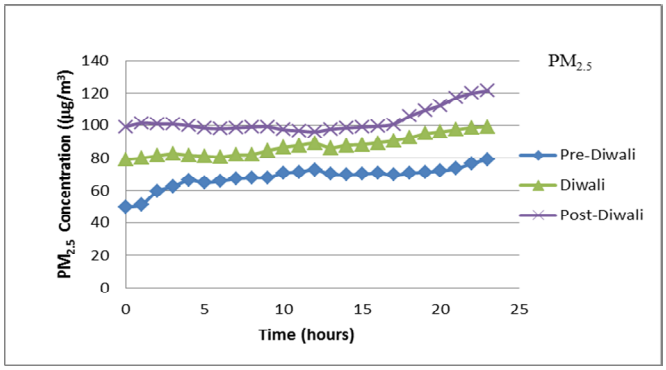

Fig.2. Concentration of $PM_{2.5}$ over three days during Diwali

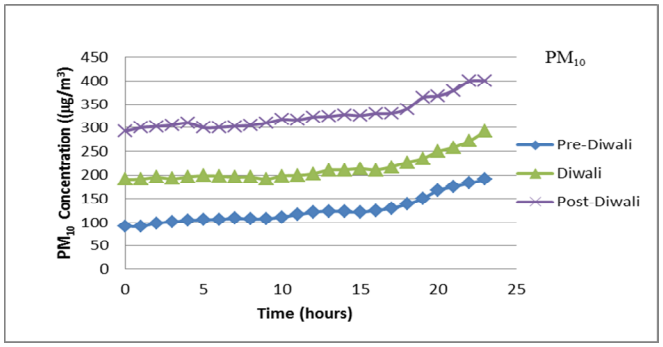

Fig.3. Concentration of PM_{10} over three days during Diwali

III. RESULTS AND DISCUSSION

Table 1 shows the standard limit of the air quality parameters as indicated in the National Ambient Air Quality Standards (NAAQS), published by Central Pollution Control Board (CPCB), New Delhi. The most critical pollutant observed during the period is PM_{10} The average concentrations of the pollutants over three days >220 μg/m^3 for PM_{10}, >86 μg/m^3 for $PM_{2.5}$. The data (Fig. 2 and Fig. 3) for PM_{10} and $PM_{2.5}$ show the highest concentration levels of 400.6 μg/m^3 and 121.5 μg/m^3 respectively. The enhanced average concentration levels of these air pollutants are due to the burning of fire-crackers and sparkles on the Diwali nights. It may be noted that during Diwali, the average mass concentrations of PM_{10} and $PM_{2.5}$ are much higher than the prescribed NAAQS limit. It is a serious threat to the environment that the particulate matter emitted by the firecrackers on the Diwali nights not only causes severe health hazards but also has a prolonged impact on the meteorological environment.

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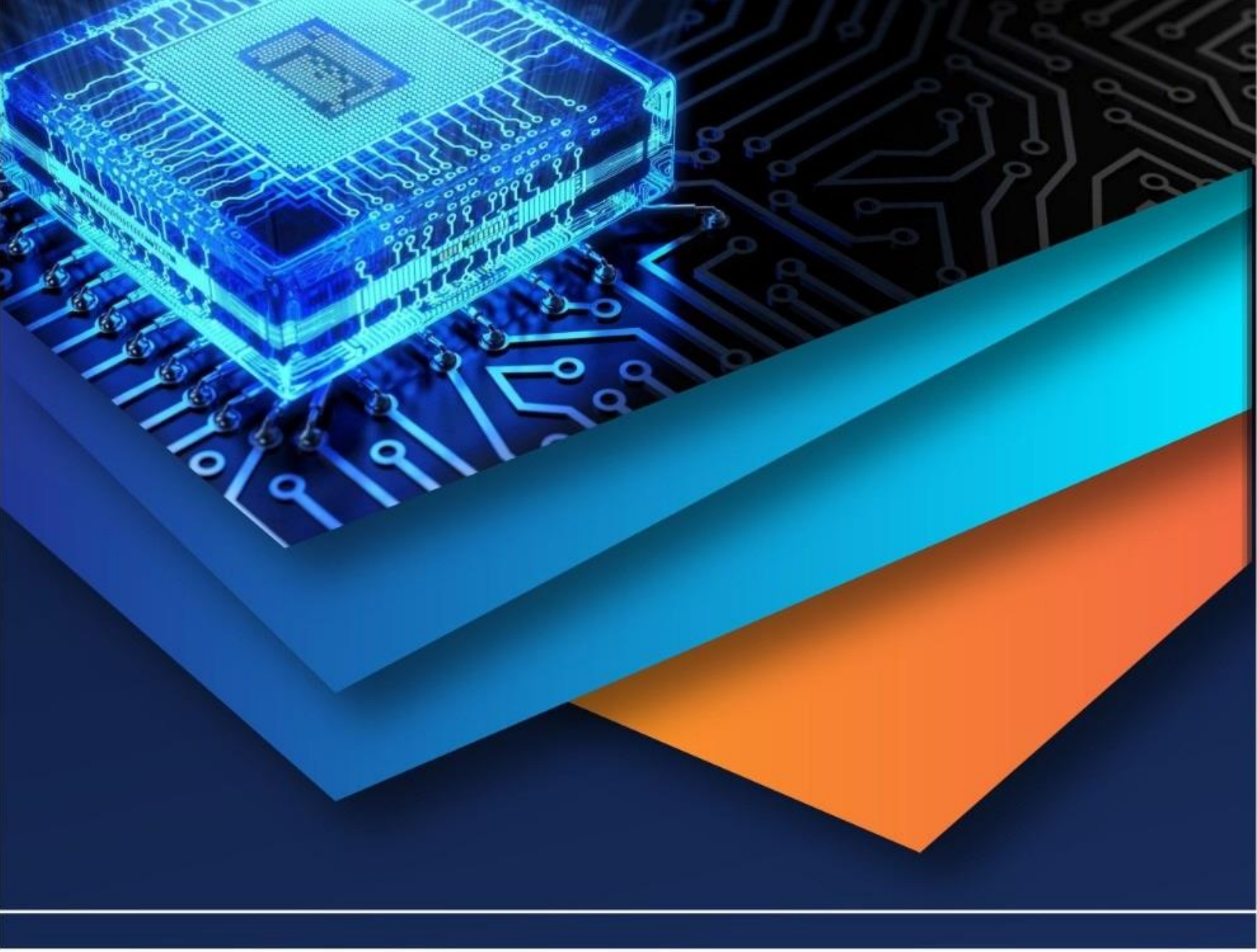

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