INVESTIGATING REAL TIME AMBIENT AIR QUALITY STATUS AND AIR TEMPERATURE DURING KALIPUJA/DIWALI FESTIVAL IN DIFFERENT LANDUSE TYPES –CASE STUDY KOLKATA

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Abstract - In India, festivals are celebrated with lot of enthusiasm and Diwali is one of the major festivalscelebrated across India as well as in Kolkata. During Diwali houses are illuminated by lights and sky is illuminated by fireworks. These fireworks although creates lot of amusement but at the same time causes pollution in the atmosphere in terms of air pollution. In 2018, we monitoredand measured air pollution level during the Diwali timein different land use areasin Kolkata,mainly at various traffic intersections at different landuse types like residential, commercial, open green areas and mixed use types before and after the festival. After the collection of data we investigatedand compared thesedata with standardair quality parameterspresprescribed by Central Pollution Control Board, India.Our study confirms $PM_{10}$and $PM_{2.5}$concentration level its highest value during evening time 1385µg/m^3 (PM_{10}) and 950µg/m^3 ($PM_{2.5}$) on7th Nov 2018 i.e. on the day of Diwali. We also observed rise in temperature on 7th Nov as well. This high concentration is maintained in atmosphere for two days on and after the festival which is approximately 9-10 times more than that regulatory standard. The aim of this study is to understand the correlation between traffic intersections in different Landuse types,the concentration of PM_{10} and $PM_{2.5}$ levels and the land surface temperaturein different areas during the festive days of Kalipuja or Diwali time, mainly the four days on 5th,6th,7thand 8thNovember 2018.

Keyword - Ambient Air Quality,PM10& PM2.5,Landuse Types, Land surface Temperature, Kalipuja& Diwali

I. INTRODUCTION

Diwali is well known as the festival of light and it is a major festival in India which is celebrated for a period of 3 days either in the month of October or November every year. During Diwali, traditionally, people of all ages enjoy burning of firecrackers. These burning of fire crackers and sparklers starts from evening to late night hours mostly in an enormous way on pre- Diwali and post-Diwali as well on the Diwali day. Air quality in megacities and other developed urban centres is a serious problem due to their high pollutant concentrations and health related issues. Short term air quality degradation episodes are gaining increased attention of the scientific community as they considerably affect human health due to their long term negative effects (pope et. al.2002,Nastoset. al.2010 Samoliet. al. 2011).During the festival days, extensive burning of firecrackers, the most unusual source of short term anthropogenic pollution which causes serious health issues. Mainly the specific air quality degradation has been reported due to bursting firecrackers on Diwali festival in India (Kulshesthaet. al.2004, Mandal et. al.2011). Atmospheric particulate matter comprises colloids of solid particles or liquid droplets suspended in the atmosphere the diameters of these particles or droplets range from 0.001 to 20µm. In particular, PM10 and PM2.5, having particulate aerodynamic diameters of less than 10and2.5µm, can easily enter the lungsand being enriched with organic pollutants, viruses, can cause serious harm to human health (L.Sun a,n, Colvileet. al., 2001; Brunekreef and Holgate,2002; Xu, 2002; Espinosa et. al.,2002; Marcazzanet. al., 2003; Kocifajet al., 2006; Huang et al., 2012). Atmospheric particulate matter can also lead to a poor atmospheric visibility by absorbing and scattering light (Liu Ju–Yan et. al., 2009; Chen et al.,2010; Han et. al.,2011). Air over Kolkata is getting polluted by traffic jams, construction works, vehicle emissions, fumes from road side tea and food stalls, careless habits of burning waste etc. National Ambient Air Quality Standards of India prescribes annual average for PM_{10} as 60 µg m^3 (The Gazette of India, 2009); which is much less compared to WHO's stringent air quality standards (WHO, 2006). Many parts of Kolkata city recorded annual average PM_{10} for the year 2012 much higher than the national average (GPCB, 2013); more than 80 µg $m^3$to 100 µg m^3 acrossthe. Kolkata city located in east corner of India where industrial growth is moderate and commercial or residential growth is highest. The city has a population of 4,496,694 (2011 census).This metropolitan city is also a big centre for commercial, educational, residential, transportation and agricultural in Ganga basin region of West Bengal state. The metro city celebrates Diwali festival in which various types of crackers are burst which generates lot of air pollution in atmosphere. By this episodic rise in PM_{10} and $PM_{2.5}$ in atmosphere and adverse effect on regional visibility, global climate change and health effect mainly respirable related. Diwali celebrated throughout India on 7th Nov, 2018 and people of West Bengal celebrated the Kalipuja on

6th Nov, 2018. On Diwali day (7th) evening after lighting candle, fireworks started and continued for two days from 6th to 7th Nov.

II. MATERIALS AND METHODS

A. Study Area

Present study area is Kolkata metropolitan, the capital of West Bengal and it is the third most populated metropolitan city which is located in the eastern part of India and linearly along the banks of the Hooghly River. Latitude and Longitude of Kolkata is 22.5667° N, 88.3667° E.

III. METEOROLOGICAL STATUS IN KOLKATA

- Kolkata has a tropical wet and-dry climate (Koppen climatic classification Aw).
- The annual mean temperature and monthly mean temperatures range is respectively 24.8 °C (80 °F); and 15 °C to 30 °C (59 °F to 86 °F).
- Summers are hot and humid with temperatures in the low 30's and during dry spells the maximum temperatures often exceed 40 °C (104 °F) during May and June.
- Winter tends to last for only about two and a half months, with seasonal lows dipping to 9 °C – 11 °C (48.2 °F – 51.8 °F) between December and January. Humidity is around 96% in the mornings and 67% in the afternoons.
- Annual rainfall of 1,582 mm (62.3 inches).

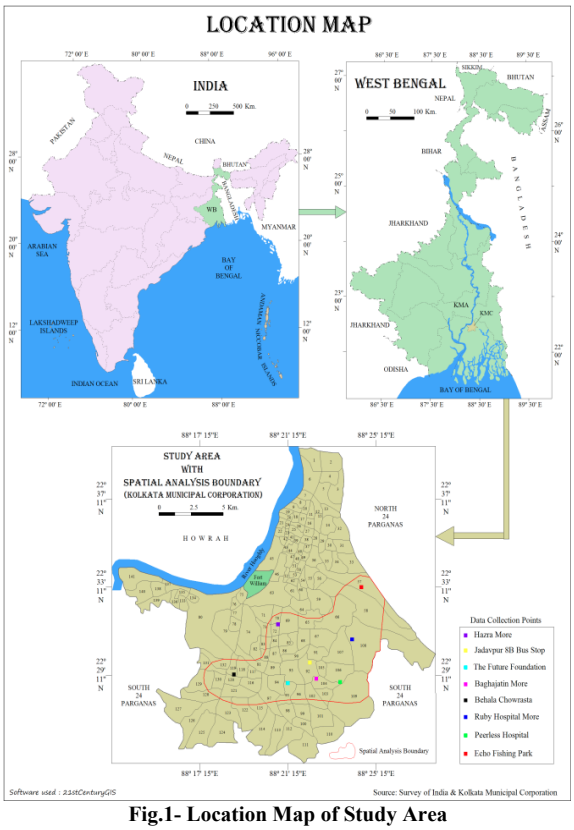


Fig.1- Location Map of Study Area

The study was carried out at eight different land use and traffic zone area at southern Kolkata (Fig.1).The first site (8B Bus stand) is situated nearJadavpur University campus at Jadavpur and others are Baghajatin More, Future Foundation School, Hazra More, Ruby Hospital More,Eco Aquatic Hub, Peerless Hospital, Behala Chowrasta.The micro-meteorological parameters like temperature (ºC) on these eight stationhave been shown in Table 1 for four days of Diwali week.

IV. METHODOLOGY

A. Data Collection

Monitoring was conducted on Pre-Diwali, Diwali and Post Diwali day during morning 8-11 a.m. and evening 6-11 p.m. Traffic count has also been done simultaneously in terms of Cars, Autos, Buses/Trucks and Motorbikes in a 15 min. interval every hour of the two hour monitoring and then converted it in hourly traffic volume in terms of PCU.

B. Instrument Used

To collect $PM_{2.5}$ and PM_{10}, sensor based monitoring device has been used named NOVA PM Sensor SDS 011. The Sensors were connected with Raspberry PI for collecting data at real time with per second interval. We also used temperature sensor DS18B20 connected with PI to collect the temperature data as well.

C. Working principle of PM sensor

1. PM sensor uses principle of laser scattering.
2. Light scatters when particles go through the detecting area.
3. Scattered light is transformed into electrical signals and these signals are amplified and processed.

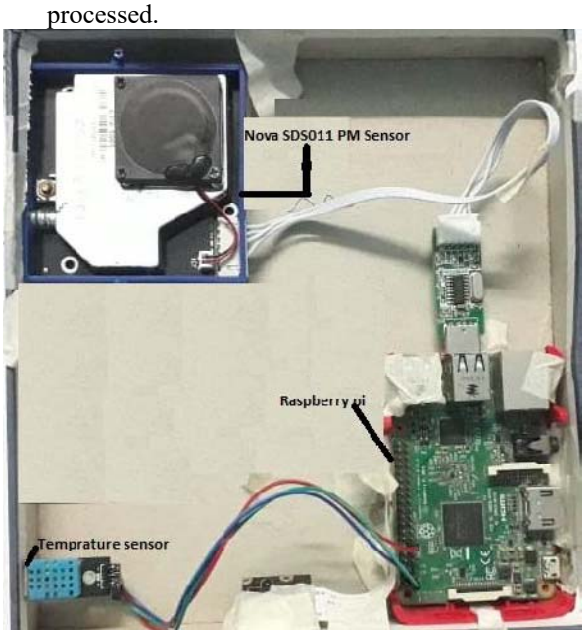
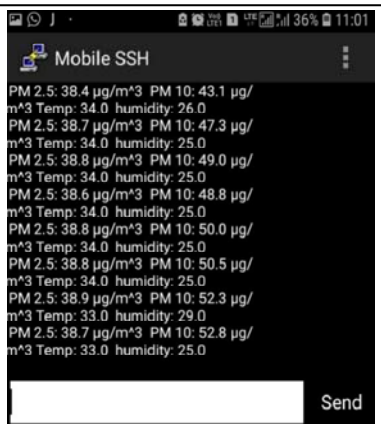


Image 4 – Complete set up of device



Sample Image of the monitoring

V. RESULT AND DISCUSSION

The study of air quality in different landuse areas like commercial,residential, open area, public and semipublic, water bodies, parks and play grounds during Diwali week (mainly pre Diwali, Diwali and post Diwali period).This study shows even with fire cracker burring the pollution level is low in residential areas due to its vegetation cover and less traffic volume like Future Foundation area(Fig 10 & 11). This is also same for open and water bodies land use pattern (like Peerless Hospital, Eco fishing Park etc). In both type of landusepatternwe observed temperature is relatively low as well. This study also confirms that commercial, public, semi-public as well as Industrial area the pollution level is very high in general due to traffic intersection, less vegetation cover which adds up more pollution during our study timedue to fire cracker burninglikethe regions BehalaChowrasta,Hazra and Ruby crossing (Fig. 10 &Fig. 11).Temperatures are also higher in those localities during our study time. Above results indicates positive relationship among pollutants, temperature and mixed land use patterns mainly traffic intersection. It is observed that PM_{10} and $PM_{2.5}$ in the morning hours(8am-11am) and night hours(6pm-11pm) was highest during the festival day. During this time most of the exposed populationtravelling for work, pandal hoppingcan have large impact on their respiration envisages. These values are approximating 9-10 times more than the CPCB(Central Pollution Control Board)standards of PM_{10}& $PM_{2.5}$ values during festival day.In India the air quality standard for PM_{10} and $PM_{2.5}$ are specified as 100µg/m3 and 60 µg/m3 respectively. The values increase due to anthropogenic activities such as bursting fireworks, roadside dust, construction activities (mainly the source of PM_{10}),other ritual activities etc.

DIFFERENT TYPES OF LAND USE MAPS SURROUNDING 500 METERS OF EIGHT DATA COLLECTION POINTS

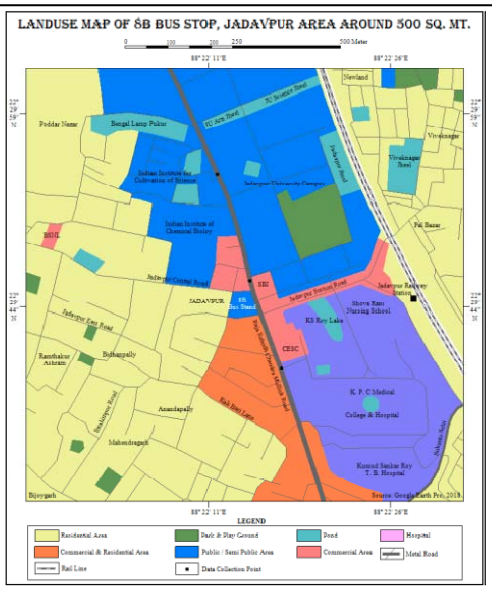


Fig.2 - Land use map of 8B Bus stand, Jadavpur



Fig.3 – Land use map of Baghajatin More

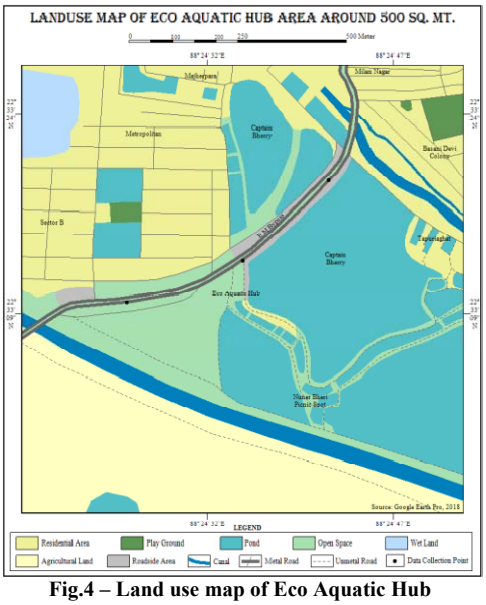


Fig.4 – Land use map of Eco Aquatic Hub

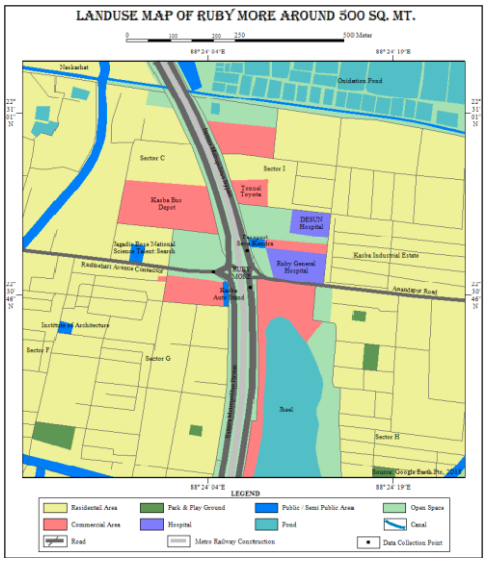


Fig.5 – Land use map of Ruby Hospital More

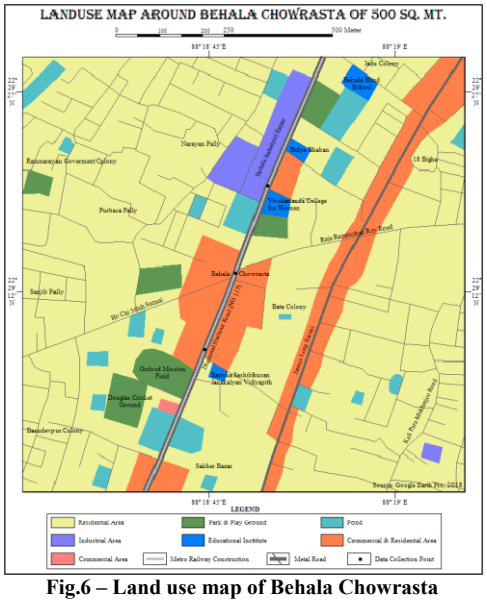


Fig.6 – Land use map of Behala Chowrasta

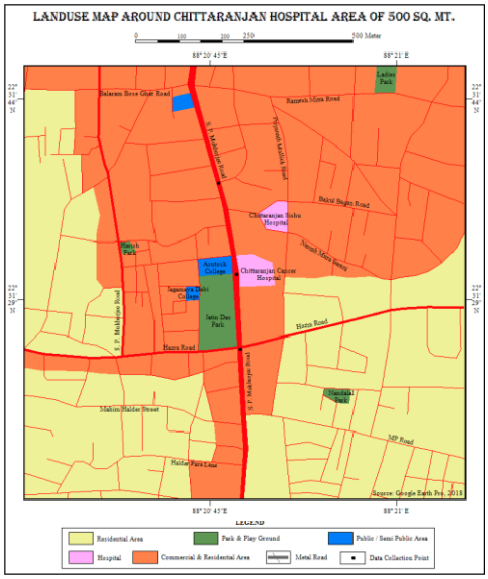


Fig.7 – Land use map of Hazra More

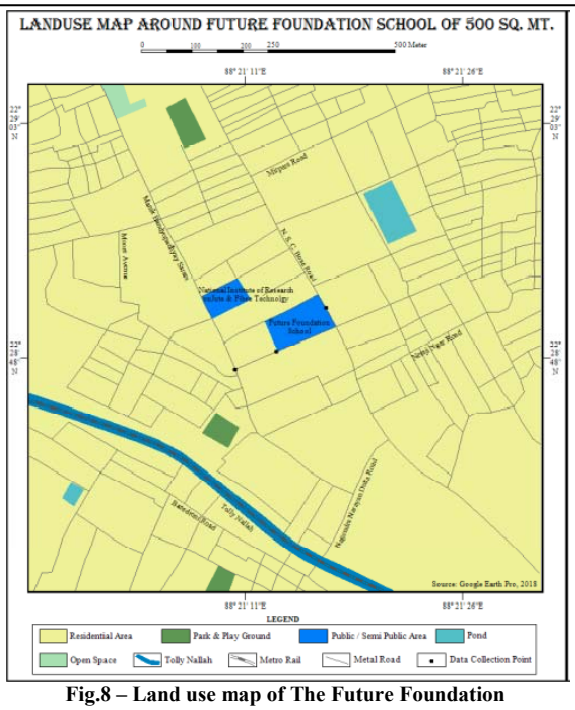


Fig.8 – Land use map of The Future Foundation

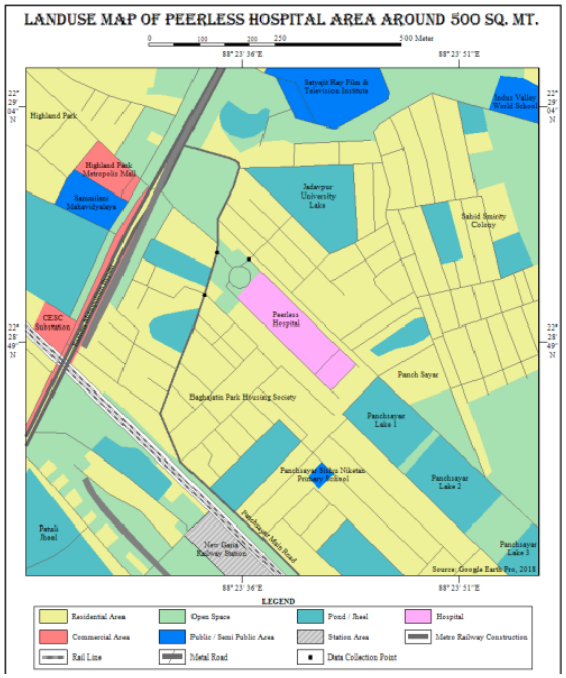


Fig.9 – Land use map of Peerless Hospital

VARIATION OF PM2.5, PM10 AND TEMPERATURE WITH RESPECT TO LANDUSE							
LOCATION	LAND USE	DAY TIME			NIGHT TIME		
		PM2.5	PM10	TEMPETURE	PM2.5	PM10	TEMPETURE
HAZRA MORE		203.6	236.65	26.67	959.90	1466.00	28.67
SB BUS STOP, JADAVPUR		188.85	238.75	26.00	958.80	1438.50	28.00
THE FUTURE FOUNDATION		165.35	165.35	25.67	738.50	1183.50	27.33
BAGHAJATIN MORE		172.65	229.55	26.67	860.90	1245.50	28.33
BEHALA CHOWRASTA		191.8	240.80	27.33	951.00	1442.50	29.33
RUBY HOSPITAL MORE		251	307.50	28.00	1052.00	1687.50	30.67
PEERLESS HOSPITAL		81.95	149.45	24.67	393.20	517.10	26.67
ECO AQUATIC HUB		117.5	183.00	25.33	472.10	529.85	27.00

Table 1 - Average ambient concentration of particulate pollutants, air temperature in the different land use zone in Kolkata for the month of November (Diwali Festival)

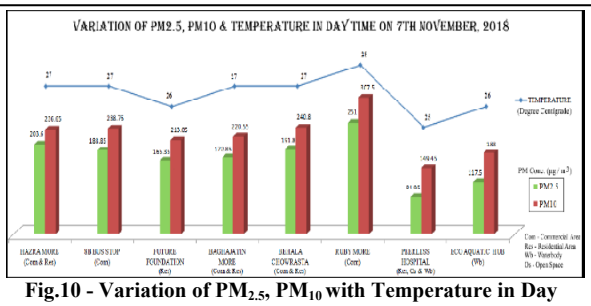


Fig.10 - Variation of $PM_{2.5}$, PM_{10} with Temperature in Day Time(during 8 AM-11 AM)

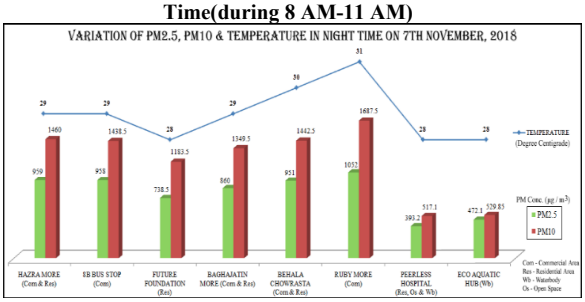


Fig.11 - Variation of $PM_{2.5}$, PM_{10} with Temperature in Night Time(during 6 PM-11PM)

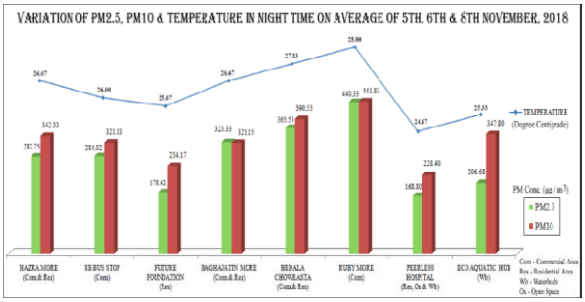


Fig.12 - Average variation of $PM_{2.5}$, PM_{10} with Temperature in the festive days on Diwali period with the respect of different land use.

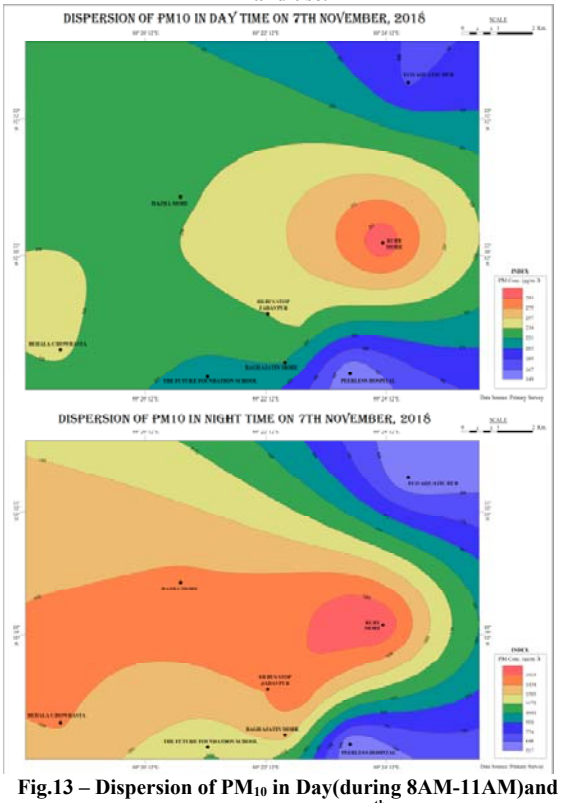


Fig.13 – Dispersion of PM_{10} in Day(during 8AM-11AM)and Night(during 6 PM-11 PM) time on 7th November,2018.

The dispersion of concentration PM_{10} & $PM_{2.5}$ is depicted in Fig.13 and Fig.14.This diagram shows the variation of concentration of PM_{10}& $PM_{2.5}$ in day and night time in Kolkata. It is also to be noted that during the day time (8AM-11AM) there were rain on the Diwali day (7th November) which reduces the pollution and air temperature to a significant level which also supports our results during day time. Whereas in the evening there were smoke like formation in the air which trapped pollutants and one of the reason for increased air temperature and their maximum concentrations on Diwali night (during 6 PM-11PM) indicating maximum firework activities during this period.

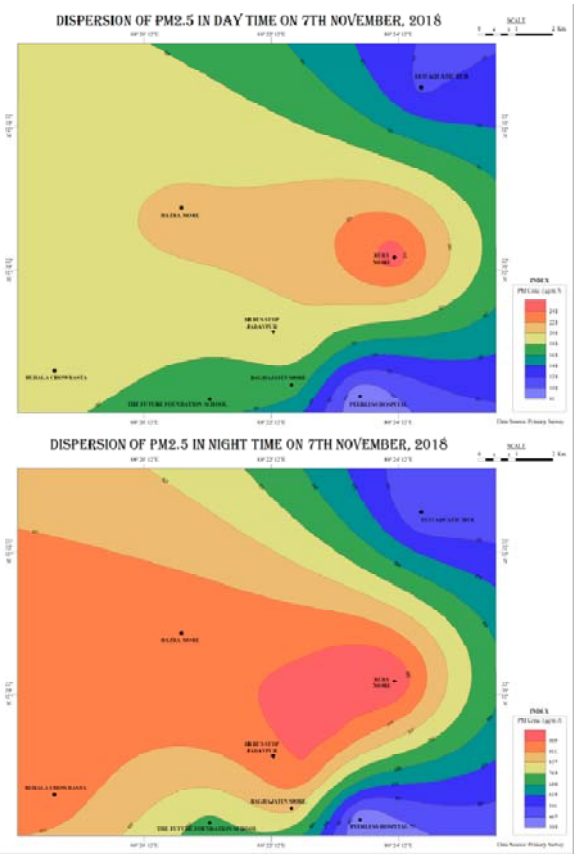


Fig. 14 – Dispersion of $PM_{2.5}$ in Day(during 8AM – 11AM)and Night(during 6 PM - 11 PM) time on 7th November,2018.

The results indicate that during the morning time the dispersion is concentrated mainly in the Ruby area (high traffic zone) whereas the concentration is remarkably low in other areas due to the heavy rain across the city which reduces the concentration of pollutantsbut due to high traffic zone at Ruby the pollution was high even with rain. The night time(study of dispersion across all area can be explained by high pollutants due to fire cracker which trapped in the air due to smoke formation in the skywhich observed in that evening. The statistical analysis,correlation coefficient and linear regression were performed between PM_{10}/ $PM_{2.5}$and temperature, during Diwali day and night(Fig 15 and Fig 16).It was observed that linear regression of

PM_{10}/$PM_{2.5}$and temperaturehas normal relationship in day time respectively R^2 >0.056 and R^2> 0.073 and R^2> 0.023 in night time respectively R^2>0.506 and R^2 >0.385 and R^2> 0.049.This statistical analysis also confirms our assumptions explained above during our discussion on result of dispersion seen on the day.

CORRELATION OF PM 2.5, PM10 & TEMPERATURE (DAY TIME)			
DATA COLLECTION POINTS	PM2.5	PM10	TEMPERATURE
HAZRA MORE	191	237.5	28.67
8B BUS STOP, JADAVPUR	166.9	243	28.00
THE FUTURE FOUNDATION	120.95	166	27.33
BAGHAJATIN MORE	130.5	201.5	28.33
BEHALA CHOWRASTA	184	215.5	29.33
RUBY HOSPITAL MORE	251	307.5	30.67
PEERLESS HOSPITAL	81.95	149.45	26.67
ECHO AQUATIC HUB	117.5	183	27.00

Table 2 - Average ambient concentration of PM_{10}, $PM_{2.5}$and air Temperature on Diwali Day(during 8AM-11AM)

CORRELATION OF PM 2.5, PM10 & TEMPERATURE (NIGHT TIME)			
LOCATION	PM2.5	PM10	TEMPERATURE
HAZRA MORE	959	1353.5	26.67
8B BUS STOP, JADAVPUR	958	1358.5	26.00
THE FUTURE FOUNDATION	738	1183.5	25.67
BAGHAJATIN MORE	860	1299	26.67
BEHALA CHOWRASTA	951	1297	27.33
RUBY HOSPITAL MORE	1052	1477	28.00
PEERLESS HOSPITAL	393.2	517.1	24.67
ECHO AQUATIC HUB	472.1	529	25.33

Table 3 - Average ambient concentration of PM_{10}, $PM_{2.5}$and air Temperature on Diwali Night (during 6 PM-11 PM)

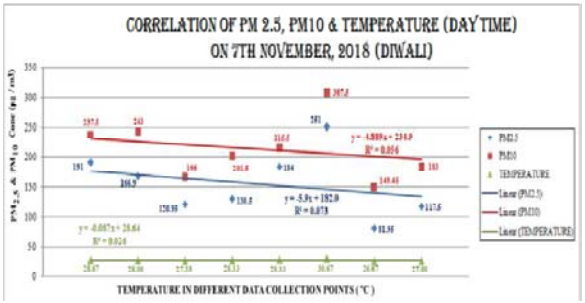


Fig.15 – Correlation of $PM_{2.5}$, PM_{10}& Temperature in Day Time on 7th November, 2018 (Diwali)

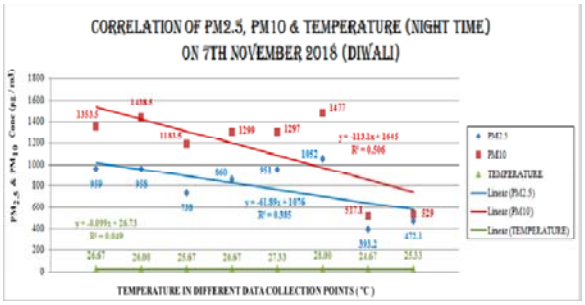


Fig.16 – Correlation of $PM_{2.5}$, PM_{10}& Temperature in Night Time on 7th November, 2018 (Diwali)

VI. CONCLUSION

Our research results confirm a positive correlation among air temperature, LULC and air quality, as already known from many other studies. Air temperature wasfound to be very sensitive to different land use categories and different air quality parameters, specially on Diwali day.

In this investigation the burning of firecrackers, sparkles and vehicular emission is the most prominent source of air pollutants over all eight study areas.It is also to be noted that late evening entry of mass in the inter-state diesel-driven heavy vehicles in the city, also contribute to elevated level of air-pollution. The result of this study suggested that the pollutants emitted from the burning of firecrackers, emission of vehicles even over a short duration may cause carcinogenic risk levels to human health.In India as this festival is celebrated all over the country. Hence, for the benefit of society, it is necessary to formulate proper strategy to control the emission and subsequent dispersion of the pollutants. Following measures may be considered:

- Firecracker display should not be promoted as a community entertainment .
- Firecracker burning must be prohibited on roads and designatedlarge open spaces for firecracker display which should be away from residential area.
- For better dispersion fire crackers who explodes at a higher elevation (above normal skyline of the locality) needs to be encouraged.

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