ASSESSMENT OF AIR QUALITY OF PATNA TOWN AT DIFFERENT MICRO-ENVIRONMENT

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Foreword

Air quality plays a critical role in the health of people. Over the years, there is a growing concern on the deteriorating air quality. Given the pace of urbanization, which is often unplanned, there is an increase in pressure on cities and towns to meet the growing demands of the urban population. This has an adverse effect on the environment, affecting air and water quality. Such adverse effects of unplanned urbanization need to be addressed with robust scientific tenacity. The assessment of air quality in the city of Patna is a step in this direction and it covers the critical winter season with a festive Diwali period which appends pollution to the existing ambient air, and needs a greater policy level intervention.

Report on air quality assessment of Patna City at different micro environments has come up in a very right time, since, Bihar State Pollution Control Board is in the verge of preparing Clean Air Action Plan. I wish to congratulate Bihar State Disaster Management Authority (BSDMA) for initiating the discourage on air pollution from a health emergency purview. I also acknowledge the efforts of Indian Institute of Tropical Meteorology (IITM), Pune for conducting this study and CEECE at the Asian Development Research Institute for collaborating with BSDMA in dissemination of the findings and outlaying the importance of air pollution as a causal factor for climate change and its diversified impacts.

I wish to congratulate the entire team of BSDMA and IITM for making this endeavor feasible, which will be useful for researchers, as well as policy makers. I am sure this study will act as a ready reference point and background for Clean Air Action Plan.

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Foreword

Air Pollution being a serious threat has led to over 7.1 million premature deaths because of outdoor air pollution and 7.8 million premature deaths because of household air pollution worldwide in 2015 (WHO, 2018). In addition to life threatening diseases such as heart disease, lung cancer, respiratory diseases, and problems related to kidney, nerves, brain, liver, whereas elevated concentration of certain pollutants can cause symptoms like dry throat, sore eyes, tickly cough, headache etc. in healthy person which can hamper daily activity of individual. Air pollution does not affect only human health but also, affects various other environmental conditions which have an either direct or indirect effect on global heat, seas on-cycle, rainfall and eventually food and water security of the countries. Bihar is not an exception because of its agrarian dependence is worst affected by the menace by negatively influencing the supply chains.

In view of unplanned rapid urbanization in Patna town, the assessment of air quality by deploying mobile van fitted with sophisticated air pollution monitoring equipments and with the help of IITM, Pune has came up in a very right time. Since, it is a matter of health emergency, Bihar State Disaster Management Authority (BSDMA) approached Indian Institute of Tropical Meteorology (IITM), Pune for carrying out the detailed inception study at 10 different micro-Environment during pre-winter season, 2017 covering Dipawali festival. This report is likely to help Bihar State Pollution Control in preparing clear Air Action Plan.

The entire team of BSDMA and IITM deserve congratulations for making this endeavour feasible. This study will help to researchers, parctitioners, as well as policy makers in further improving the outcome and suggesting measures for improvement of Air Quality Index (AQI). On the basis of the outcome of a national workshop held on 09th May, 2018, Patna Declaration on Air Pollution has been conceived as endorsed by the delegates and experts who attended the workshop.

(Vyas Ji)

About the Air Quality Assessment Study in Patna

Air quality plays a critical role in the health of people. Over the years, there is a growing concern on the deteriorating air quality. Given the rapid urbanization, which is often unplanned, there is an increase in pressure on cities and towns to meet the growing demands of the urban population. This has an adverse effect on the environment affecting air and water quality. Such adverse effects of unplanned over urbanization need to be addressed with robust scientific tenacity.The assessment of air quality in the city of Patna is a step in this direction and it covers the critical winter season with a festive Diwali period thatappends pollution to the existing ambient air.In all 9 microenvironments of Patna city were covered in 2017 in this assessment.

Air is a mixture of various gases; important for survival of human race and life on the Earth, in a fixed proportion; it's a life supporting system.But if the composition of air alters then elevated concentration of certain trace gases can lead to detrimental effects on human health and our environment. As a by product of all our daily activities, various contaminants continuously enter the atmosphere, as well as several natural processes contributing to large mass of contaminants which interact with the environment causing environmental pollution, toxicity and diseases. Air Pollutants are any solid, liquid or gaseous substance present in the atmosphere in such concentrations that tend to be injurious to human beings, other living creatures, plants, property and environment.

Globally, the potential threats of deteriorating environment are not only being felt but also being determined by several scientific studies. Several research studies have proved that deteriorated air quality is associated with increased health problems. This is an alarm for us; we have to find out reasons behind this unseen danger. If not prevented things could get worsen.

Air Quality representation for an urban conglomeration is a complex issue. One of the most common errors in this is to define the air quality in a city based on single station data. According to the International Guideline, an index needs to be created for the city based on air quality of different micro- environments. In the current Patna pilot project a mobile van equipped with several sophisticated instruments was deployed in Patna at apoint of time to cover the determined monitoring period of air quality assessment during October and November 2017.The online sophisticated US-EPA approved instruments simultaneously monitors a range of criteria pollutants including Particulate Matter (PM10: Particles having size less than 10 0µm; PM2.5: Particulate Matter having size less than 2.5 µm), Ozone (O3), Carbon Monoxide (CO), Sulphur Dioxide (SO2), Nitrogen Dioxide (NOx). In addition, the afore-mentioned mobile van is also equipped with meteorological parameters such as temperature, humidity, wind speed, wind direction, solar radiation and UV radiation.

Post analysis, one of the most critical aspects of any endeavour on air quality is 'communicating alerts and advisories to the public. This pilot study provided the information on current status of air quality, weather and harmful radiation over the city area in a very simple and user-friendly format in terms of AQI (Air Quality Index) and UVI (Ultraviolet radiation Index).Air Quality Index (AQI) is a rating scale used for reporting the quality of air we breathe in & the associated health effects.The UVI is a measure of

the amount of skin damaging UV radiation expected to reach the earth's surface at the time when the sun is highest in the sky. As the world around us changes, science should be used for improving the standards of living of people. This is precisely what we aim to achieve through this endeavor. Our future vision is to provide authentic air quality information to the public along with its forecast as part of an early warning system for enabling the people to mitigate the adverse effects of air pollution. Such a system is useful for various sectors including Health, Agriculture, Aviation, Urban Planning and Urban Development, Disaster Management, Tourism, etc. This early warning early action system is capable of generating knowledge products of economic value for awareness generation, evidence based policy advocacy and implementation of improving air quality by polluting emission programmes. It would play a pivotal role in achieving inclusive and sustainable growth. Such advancement in knowledge base will help reduce the total costs of environmental damage resulting in better health status of people.

This important work plan to assess air quality at strategically important and unique locations in Patna, Bihar is conceived as part of larger plan under SAFAR (System of Air Quality and Weather forecasting And research) where this valuable data will help in understanding the air quality of Patna city. The SAFAR-2017 requirement of IITM, the requests from Bihar State Disaster Management Authority (BSDMA), Government of Bihar converged at same time and resulted in designing the current Pilot study of Patna. We are indebted to Secretary of BSDMA, Sri Sanwar Bharti for his enthusiasm, whole hearted cooperation and logistic support for this project. We are thankful to Senior Advisor(Env. & Climate Change), BSDMA, Shree Ajit K. Samaiyar for his support and cooperation for this project.

We acknowledge with thank for the cooperation of Ms. Shivani Gupta, Project Officer (Env. & Climate Change),BSDMAfor her assistance in the project to meet the physical and technical needs,for smoothly running the measurement programme. Finally, we express our sincere gratitude to Secretary, MoES (Govt. of India) and Director, IITM, for providing all necessary support for this study. We also thank all officials and persons associated directly or indirectly with this project.

(GuffranBeig)

Project Director, SAFAR

Contents

List of Figures

List of Tables

Acronyms and Abbreviations

AQI	Air Quality Index
CO	Carbon Monoxide
CO2	Carbon Dioxide
CPCB	Central Pollution Control Board
GHG	Green House Gases
H	Hour
IITM	Indian Institute of Tropical Meteorology
km	Kilometer
m	Meter
MoES	Ministry of Earth Sciences
NAAQS	National Ambient Air Quality Standards
NO2	Nitrogen Dioxide
O3	Ozone
PM10	Particulate Matter with cut off diameter 10 micrometer
PM2.5	Particulate Matter with cut off diameter 2.5 micrometer
ppb	Parts per billion
RPCB	Rajasthan Pollution Control Board
SOx	Sulfur Oxide
UNICEF	United Nations Children's Fund
UV	Ultraviolet radiation
UVI	UV Index
VOC's	Volatile Organic Compounds
WHO	World Health Organization
$\mu g/m^3$	Microgram per cubic meter

1. Introduction

Deteriorating air quality has become one of the biggest challenges in the world.

Air pollution is identified as world's single largest environmental health risk,and hence extensive studies are being done to analyze the health risk due to air pollution. Due to rapid urbanization and our growing needs, majority of regions in India, especially state capitals, have become major centers for commerce and industries. Probably these activities are leading to unplanned growth and hence impose notable adverse impacts on the local and regional air quality. Hence this issue needs an urgent pre requisite scientific assessment.

Air pollution being a serious threat has lead to over 3.7 million premature deaths because of outdoor air pollution and 3.8 million premature deaths because of household air pollution worldwide in 2012 (WHO, 2016). In addition to life threatening diseases such as heart disease, lung cancer, respiratory diseases, and problems related to kidney, nerves, brain, liver, elevated concentration of certain pollutants can cause symptoms like dry throat, sore eyes, tickly cough, headache etc. in healthy person which can hamper daily activity of individual. Air pollution does not affect only human health but also, affects various other environmental conditions which have an either direct or indirect effect on global heat, season-cycle, rainfall and eventually food and water security of the countries.

In India, the problem of air pollution gained ground after the release of the study titled Global Burden of Disease, which states that outdoor air pollution was the fifth largest killer in India and around 6,20,000 early deaths occurred from air pollution related diseases. The problem is more severe in Tier-1 (Population $\geq$ 1 lakh) and Tier-2 (Population between 50,000 to 99,999) cities of India including Delhi, Patna, Gwalior, Raipur, Ahmadabad, Firozabad, Amritsar, Kanpur, Agra, Ludhiana because of uncontrolled urbanization, surge in industrialization, escalating construction activities and shoot up in transportation activities. Fossil fuel combustion in industries, vehicle engines and energy sector, biofuel burning in domestic sector, waste disposal practices including open biomass burning, poor road conditions, windblown dust from unpaved road sides are some of the major pollution sources which can be easily located in any growing city of India.

These sources emit various health hazardous pollutants into the atmosphere, including PM 10 (Particulate Matter of size $\leq$ 10 µm), PM 2.5 (Particulate Matter of size $\leq$ 2.5µm), CO, NOx (NO+NO2), SO2, VOC's etc. and Green House Gases (GHGs) such as CO2, methane, and N2O. It also triggers formation of secondary aerosols and pollutants such as O3 under certain meteorological conditions. When concentration of these pollutants exceeds certain threshold limits, they show a negative impact on human health and the surrounding environment. Most vulnerable groups include children and elderlies who have greater susceptibility to various infections.

Patna, the capital city of Bihar has witnessed a rise in pollution levels in recent years as is the case in many other cities in India. During the last decade (2001-2010) as per the Central Pollution Control Board (CPCB) report 2012, Patna city has recorded increasing trend in pollutant like PM 10 and exceeds the NAAQS standard limit. A World Health Organization survey declared Patna the second most air polluted city in India, only after Delhi, with the survey calculating the PM2.5 in

the state capital's ambient air to be 149 μg/m^3 in 2014. According to the CAG report, tabled in the Bihar Legislative Assembly in April 2015, level of PM 10 in Patna was 355 μg/m^3 i.e., three-and-a-half times higher than the prescribed limit of 100μg/m^3 this is, primarily due to high vehicular and industrial emissions and construction activities in the city.

There are number of studies and monitoring data reported from a specific location in Patna, however, a comprehensive study to understand the level of various air pollutants and the overall status of air quality in Patna in different micro-environments including different sectors such as industrial, residential, traffic locations, commercial locations, and a background clean area i.e. control site is being studied under this assessment. Patna city has many cultural sites and is also a major trading Centre.

The current report is an attempt in this direction and provides a pilot analysis of Patna air quality where first-hand status of prevailing air quality in 8 different micro-environments of Patna city during winter season is addressed by state of the art advance monitoring online analyzers.

The present study has been conducted in Patna city from 19th October 2017 to 28th November 2017, during which levels of major criteria pollutants such as PM 10, PM 2.5, Ozone, CO, NO2 and SO2 along with meteorological parameters including temperature, humidity, wind speed, wind direction and UV radiations have been continuously monitored at strategically selected micro-environments in the city area by using state of the art mobile van equipped with US-EPA approved analyzers.

2. Patna Town

Patna, the capital city of Biharis situated along the south bank of the Ganges River in Bihar, north east India. The population of Patna city is 1,683,2001 comprising a total area of about 125 km^2. The co-ordinates of city are 25.6^0N and 85.1^0E. Patna is one of the oldest continuously inhabited places in the world. Patna was founded in 490 BCE by the king of Magadha. The partition of Bengal presidency in 1912, made Patna the capital city of Bihar.

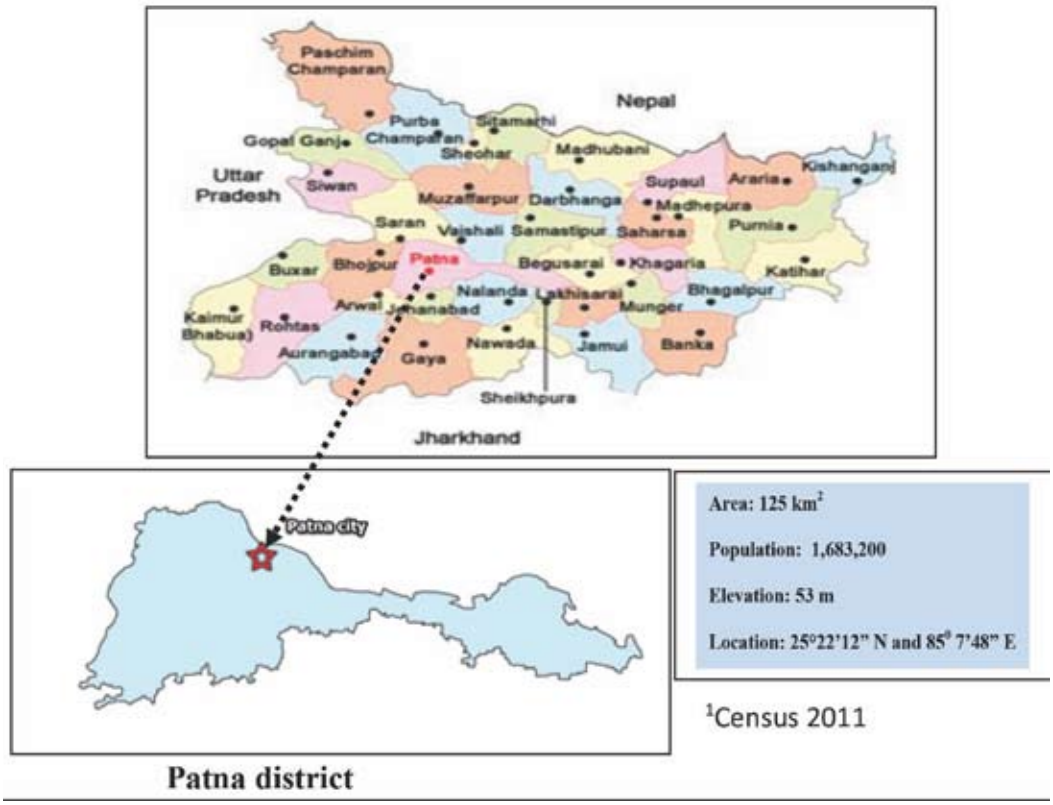


Figure 1: Location of Patna city.

The modern city of Patna is situated on the southern bank of river Ganges. River Punpun flows south of township limit and Ganga river is its Northern limit. The township and surrounding is underlain by thick fluvial sediments deposited by river and its tributaries. It is the largest riparian city in the world. The topography of Patna city is saucer shaped as per Patna City Development Plan prepared in 2006.

Patna city has a tropical type humid climate characterized by three distinct seasons, with extremely hot summers from late March to early June, the monsoonseason from late June to late September and chilly winter nights and foggy or sunny days from October to February.The daily average temperature remains up to 29^0C. The maximum temperature varies between an average of 41^0C to 47 ^{0}C in summer season and as low as 9-10 ^{0}C in winter season. The recorded lowest temperature was 1.1^0C on 9th January 2013. The annual rainfall of 1109.8mm is received through South Western monsoon between the periods June to September in the city.

3. Project Design and Monitoring

3.1. Monitoring sites

Table- 1: Details of monitoring locations in Patna and period of monitoring.

Sr. No.	Site Name	Period	Type	Latitude	Longitude
1	Pant Bhavan	19th-23th Oct	Traffic junction	25.607388^{0}N	85.116937^{0}E
2	Aryabhatta knowledge University	24th-28th Oct	Commercial Area	25.592302^{0}N	85.134929^{0}E
3	Patna College	29th-2nd Nov	Green area	25.620870^{0}N	85.165574^{0}E
4	Pollution Control Board	3th- 07th Nov	Industrial area	25.636161^{0}N	85.104733^{0}E
5	Bihar veterinary college	08th - 12th Nov	Background cleaner site	25.599931^{0}N	85.084865^{0}E
6	Nalanda Medical College And Hospital	13th-14th Nov	Residential Area	25.600308^{0}N	85.173958^{0}E
7	Pant Bhavan	15th-16th Nov	Traffic junction	25.607388^{0}N	85.116937^{0}E
8	Nalanda Medical College And Hospital	17th-19th Nov	Residential Area	25.600308^{0}N	85.173958^{0}E
9	Walmi	20th-24th Nov	Forest Area	25.571816^{0}N	85.046484^{0}E
10	Maurya lok complex	25th-28th Nov	Commercial/Traffic	25.609599^{0}N	85.134317^{0}E

Table 1 and figure 2 represents the details of eight monitoring sites and geographical locations. To know the current status of the ambient air quality in the city, 41 days campaign was conducted from 19th October 2017 to 28th November 2017. The main objective was to generate a robust database on the concentration of hazardous pollutants (PM10, PM2.5, Ozone, CO, NO2, SO2) in the air. As weather plays a crucial role in determining the pollution levels, simultaneous monitoring of all meteorological parameters including temperature, humidity, wind speed, wind direction, UV radiation was also carried out. To get a true representation of the air quality in the city and to assess the impact of various activities on pollution levels, 8 monitoring sites representing various micro-environments have been selected. These micro environments included industrial, residential, urban downtown, commercial, traffic junctions and background sites.

Figure 2: Geographical locations of monitoring stations in Patna city.

Pant Bhavan lies on North Western side of the main city adjacent to boring canal road and with a near landmark Sri Krishna Puri. It is a traffic junction due to congestion of roads at a place. Aryabhatta Knowledge University lies in the southern part of city which is a commercial area. Patna college lies in the northern

part of city maintained with the natural habitat and hence considered as green area. Pollution control board lies on the North West side near Patliputra industrial area which is surrounded by many industries like pipe manufacturing, plastic fabrication, Paint manufacturing, etc. Bihar veterinary college lies on the western side of city near to airport road and surrounded by greenery with no potential pollution sources and hence is considered as Background cleaner site. Nalanda medical college and hospital is situated in the eastern part of the city which is a residential area at Agamkuan. Walmi is a forest area covered with more vegetation situated at the south western part of city near phulwarisharif. Maurya lok complex is a commercial area near Bandar Bagicharoad comprising of shopping plazas, hotels, etc.

3.2 Measurements

The monitoring was carried out using state- of– the - art Mobile Air Quality Monitoring Laboratory (MAML) (Figure-3) which monitors air and weather parameters, round the clock. MAML is well equipped with advanced online analyzers approved by United States Environmental Protection Agency (US-EPA). Measurement of particulate matter was done using the MP101M analyzer, which works on the principle of cyclic measurement by Beta gauge. The concentration of ozone was monitored with the help of online ozone analyzer (Model: O3 42M, Environmental-SA France). This instrument works on the principle of Ozone Absorption Spectrum. The analyzer draws ambient air using a suction pump. The air is passed through the filter and is analyzed at 254 nm wavelength. Accuracy of the analyzer is high at 1 ppb. CO was monitored by the Model CO12M, which operates on the principle of IR absorption spectrum whereas NOx measurements were carried out by the AC32M model which works on the principle of Chemiluminescent. Details of both the analyzers and their measurement techniques can be obtained from the manuals /websites. On-line mode of operation permits a real time measurement and an on-line output of the volume mixing ratio as well as mass concentration of the particulate and gaseous pollutants in the ambient air. The PM10, PM2.5, O3, CO and NOx analyzers along with the temperature, humidity, wind speed, wind direction and UV radiation sensors were operated continuously during the period of observations. Data was recorded at an interval of every 15 minutes which was then averaged to onehour interval for further analysis. It has to be mentioned here that the data was passed through various quality checks (stray readings of the analyzers were first removed and then Gaussian Filter was used for quality control) before initiating further analysis.

Figure 3: Mobile Air Monitoring Laboratory (MAML).

The daily 24-hour average (01:00 H to 24:00H) values of PM10, PM2.5, and NOx and daytime 8 hr average (10:00 H to 18:00

H) values of O3 and CO obtained from the hourly generated data have been analyzed further to observe the trend at each of the monitoring sites and the same data has also been analyzed in terms of Air Quality Index (AQI).

3.3 National Ambient Air Quality Standards and Air Quality Index (AQI)

3.3.1. National Ambient Air Quality Standards (NAAQS)

The National Ambient Air Quality Standards (NAAQS) is a threshold level for a safer limit of a normal healthy person. Any

value above NAAQS is likely to be harmful to human health. It is an important component of national risk management and environmental policies. Each country has its own NAAQS which varies from country to country based on the approach adopted for balancing health risks, technological feasibility, economic considerations and various other political and social factors, which in turn depends on the level of development in the country and national capability in air quality management. The NAAQS for India for pollutants under consideration in the report are given in Table-2.**Table-2:** National Ambient air Quality Standards for India as per standard and unit of NAAQM.

Parameter	Average time	NAAQM Unit	NAAQS limit	NAAQS (Unit converted)
PM_{10}	24 hravg	µg/m³	100	100 (µg/m³)
$PM_{2.5}$	24 hravg	µg/m³	60	60 (µg/m³)
CO	8 hravg	mg/m³	02	1.7 (ppm)
O_3	8 hravg	µg/m³	100	50 (ppb)
NO_2	24 hravg	µg/m³	80	43 (ppb)
SO_2	24 hravg	µg/m³	80	30.53 (ppb)

Source: CPCB, 2009 Notification.

3.3.2 Air Quality Index (AQI)

NAAQS is not sufficient to provide the detailed information about the severity of the impact of pollutants based on which advisories can be issued. This categorization of impacts scale needs to be done for all those values which are above NAAQS. In addition to this, there should be a methodology by which the data can be converted into information, which can be easily understood by the common citizens. For this purpose, a term called Air Quality Index (AQI) is coined which is common as per the international norms.

The AQI is a scale designed to indicate the air quality around us in terms of its effects on an individual's health. AQI primarily communicates a unit less number divided in to several ranges as 0-50, 51-100, 101-200, 201-300,301-400 and 401-500+ and classified as levels of pollutants as 'good', 'satisfactory' 'moderate', 'poor', 'very poor' and 'severe' respectively.

Each of the AQI categories is decided based on the ambient concentration values of air pollutants and their likely health impacts known as health breakpoints. The higher the number, the greater is the health risk associated with air quality. It is an early warning tool with health advisories with the aim of protecting oneself from limiting short term exposure to air pollution as well as

making changes in outdoor activities. This index pays particular attention to people who are sensitive to air pollution and advises them on how to protect their health during air quality levels associated with low, moderate, high and very high health risks. Therefore, Air Quality Index is a tool for effective communication of air quality status to people in easy to understand language. It transforms complex air quality data of various pollutants into a single number (index value), nomenclature and colour. The AQI and its corresponding breakpoints designed for Indian cities are listed in Table-3, whereas, the health effect statement for each AQI category is given in Table-4.

Table-3: AQI sub index and breakpoint pollution concentration for India.

AQICategory (Range)	PM10 24-hr	PM2.5 24-hr	NO2 24-hr	O3 8-hr	CO 8-hr (mg/m^3)	SO2 24-hr
Good(0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800
Verypoor (301-400)	351-430	121-250	281-400	209-748*	17.1-34	801-1600
Severe (401-500)	430+	250+	400+	748+*	34+	1600+

Source: Beig et al., MoES Technical Scientific Report, 2010 and CPCB, 2014

Table-4: Health statement for AQI categories.

Air Quality Index (AQI)	Associated Health Impact
Good (0-50)	Minimal Impact
Satisfactory (51-100)	May cause minor breathing discomfort to sensitive people
Moderate (101-200)	May cause breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease, children and older adults
Poor (201-300)	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease with short exposure
Very Poor (301-400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases
Severe (401-Above)	May cause respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases. The health impacts may be experienced even during light physical activity

3.3.3 Ultra-Violet Index (UVI)

Exposure to sunlight at an appropriate time and upto certain extent is essential for production of

vitamin D in the human body. However, prolonged exposure to ultra violet radiation (UV-A, UV-B) is harmful to human skin. Prolonged human exposure to solar UV radiation may result in acute and chronic health effects on the skin, eye and immune system. Sunburn (erythema) is the commonly the result of the acute effect of excessive UV radiation exposure. Longer exposure to UV radiation induces degenerative changes in cells of the skin, fibrous tissues and blood vessels leading to premature skin aging, actinic keratoses. Another long-term effect is the inflammatory reaction of the eyes. According to the World Health Organisation (WHO) estimates, worldwide, about 12 to 15 million people, annually, become blind as a result of cataracts of which up to 20% may be caused or enhanced by sun exposure. Furthermore, environmental levels of UV radiation may suppress cell-mediated immunity and thereby enhance the risk of infectious diseases and limit the efficacy of vaccinations. Both of these act against the health of poor and vulnerable groups, especially children of the developing world.

WHO has published a report entitled "Global burden of disease from solar ultraviolet radiation"(2006) that provides detailed estimates of UV-associated disease burden worldwide. Using established methodology and best available estimates on UV- related mortality and morbidity, this report estimates that annually around 1.5 millions DALYs (Disability-adjusted life years) are lost through excessive UV exposure globally. The report gives region, age and sex-specific estimates and includes detailed methodological considerations.

The UV Index (UVI) is a measure of the amount of skin damaging UV radiation expected to reach the earth's surface at the time when the sun is highest in the sky (around midday). UVI on the scale of 1 to 10+ provides information about the expected risk of overexposure to the sun. The scale is divided in to five categories viz. 1-4 (No Risk), 5 (Low risk), 6-7 (Medium risk),

8-9 (High risk) and 10+ (Critical). Each category has a specific colour code and associated skin advisory that will help public to take first hand precautionary measures and protect themselves from harmful solar radiation. Table- 5 gives details of UVI and associated skin advisories developed by scientist at IITM, MoES

Table-5: UVI and associated health statement for Indian cities.

Sr. No.	UV- Index (Range)	Risk Level	Skin Advisory
01.	1 to 4.9	No-Risk	No health risk to general public.
02.	5 to 5.9	Low Risk	Little risk of harm from unprotected sun exposure. It is advisable to use UV-protective accessories for sensitive people; general public are less likely to be affected.
03.	6 to 7.9	Medium	Sensitive people are at risk of harm from direct exposure to sun. It is advisable to use UV-protective accessories by general public as
04.	8 to 9.9	High Risk	All people are at risk. It is advisable to avoid direct sun exposure.
05.	10+	Critical	All people are at high risk. It is advisable to avoid direct or indirect sun exposure.

Source: SAFAR-MoES, IITM, Pune.

4. Results and Discussion

4.1 Patna air quality

Table- 6: Average concentration values of pollutants for monitoring period at each location of Patna city.

Location	PM 10 (µg/m^3)	PM 2.5 (µg/m^3)	O3 (ppb)	NO2 (ppb)	CO (ppm)	SO2 (ppb)
Pant bhavan (Oct.)	163.11	115.38	13	15.91	1.08	5.56
Aryabhatta knowledge university	140.07	99.95	31	10.46	0.88	5.65
Patna college	123.83	87.12	33	6.76	1	5.46
Pollution control board	149.21	107.62	32	9.67	1.22	7.66
Bihar veterinary college	222.38	179.03	21	11.93	1.6	6.09
Nalanda medical college and hospital	161.614	119.03	30.4	11.38	1.377	5.81
Walmi	180.17	129.18	37	8.87	1.64	5.66
Maurya lok complex	281.24	219.9	25	19.22	1.83	7.01
Pant Bhavan (Nov.)	104.23	72.87	16	13.17	1.56	5.81

The above table depicts average concentration values of pollutants during monitoring period at each location, wherein each location has been monitored for 4-5 days Pant Bhavan (Oct.) has been monitored from 19/10/2017 to 23/10/2017 which was the festive period of Diwali, at Aryabhatta knowledge university from 24/10/2017 to 28/10/2017, at Patna college from

29/10/2017 to 2/11/2017, at Pollution control board from 3/11/2017 to 7/11/2017, at Bihar veterinary college from 8/11/2017 to 12/11/2017, at Nalanda medical college and hospital from 13/11/2017,14/11/2017 and 17/11/2017 to 19/11/2017 the period between 14/11/2017 and 17/11/2017 i.e., on 15/11/2017 and 16/11/2017 was utilized to monitor Pant Bhavan (Nov.) location in the month of November to determine the variation in air quality during the festive period of Diwali and normal location activities. A typical variation was observed between these two monitoring methods of the same location where the festive period shows higher concentration of particulate pollutants due to burning of fire crackers.Proceeding, the monitoring at Walmi location was done from 20/11/2017 to 24/11/2017 and at Maurya lok complexform 25/11/2017 to 28/11/2017.

4.1.1 Particulate matter (PM 10 and PM 2.5)

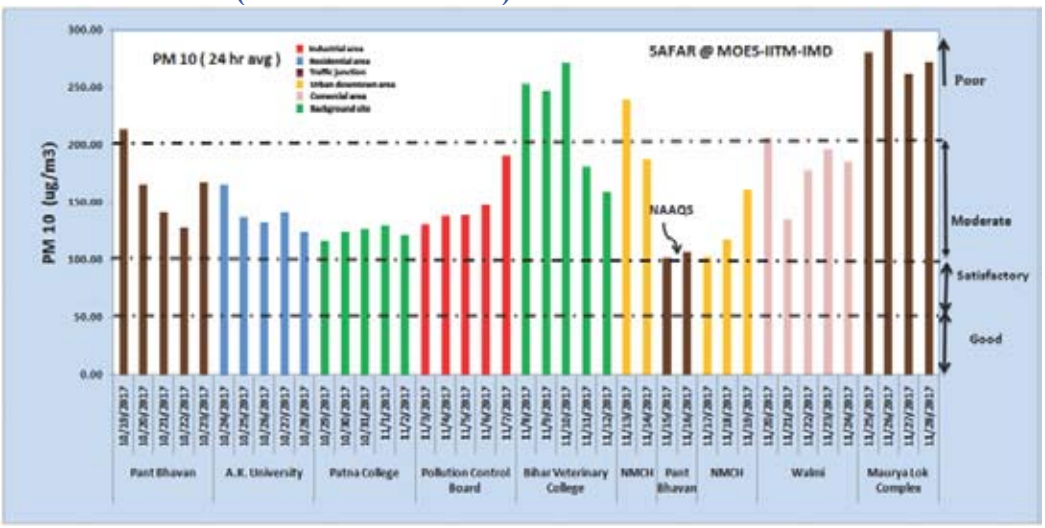


Figure 4: Daily variation in PM10 concentration during 19/10/2017 to 28/11/2017 at monitoring sites in Patna.

Daily variation of PM 10 and PM 2.5 for the monitoring period 19/10/2017 to 28/11/2017 at 9 locations is shown in Figure 4 and Figure 5 respectively. Each location has been monitored for 5 consecutive days. Pant Bhavan has been monitored seven days, priorly in the month of October for 5 days i.e., from 19/10/2017 to 23/10/2017 and then two days, 15/11/2017 and 16/11/2017 in the month of November to monitor the variation in monthly average.

The above figure illustrates maximum concentration of PM10 is to befound at Maurya lok Complex being 310µg/m^3 as daily average on 26/11/2017, which is a commercial/traffic site. The reasons behind this is due to load of traffic emissions.The average concentration for the assessment period is found to be 281.43µg/m^3 for the above site, which is ~2 times higher than the standard NAAQS limit which is 100 µg/m^3. This is followed by Bihar veterinary college with an average concentration of 222.38 µg/m^3. Daily concentration at this site ranged between 158.83 µg/m^3 to 271.88 µg/m^3, which is also above the standard limit. This may be due to the dust up dwelling in the particular location. This is followed by Walmi with an average concentration of 180.17 µg/m^3 which is an commercial site, daily average at this site ranged between 134.85 µg/m^3 to 206.16 µg/m^3. Pant Bhavan being a traffic site has an average concentration of 142.26 µg/m^3 in the month of October while 103.14µg/m^3 in the month of November the daily concentration for this site in both the months ranged between 101.43 µg/m^3 to 213.55 µg/m^3. Nalanda Medical college and hospital is a residential area with an average concentration of 141.27 µg/m^3 and daily concentration ranging between 102.36 µg/m^3 to 239.64 µg/m^3. Pollution control board being an industrial location has an average concentration of 133.03 µg/m^3 and a daily average ranging between 130.86 µg/m^3 to 190.60 µg/m^3. Others including Aryabhatta knowledge university and Patna college have average concentration 126.9 and 116.1 µg/m^3 respectively. From which one is residential area and the other is background control site. Pant Bhavan (Nov.) has an average of 104.23 µg/m^3 concentration, this monitoring has been done for two days to analyze the air quality variation in two months and to analyze the true air quality of Pant Bhavan location as the Pant Bhavan (Oct.) concentration is as on the Diwali festive day. This strategy of monitoring a location for two different time periods according to environmental changes is proved literal as there is difference of 58.88 µg/m^3 concentration of PM 10 in October month (Diwali day) and November month (Normal day).

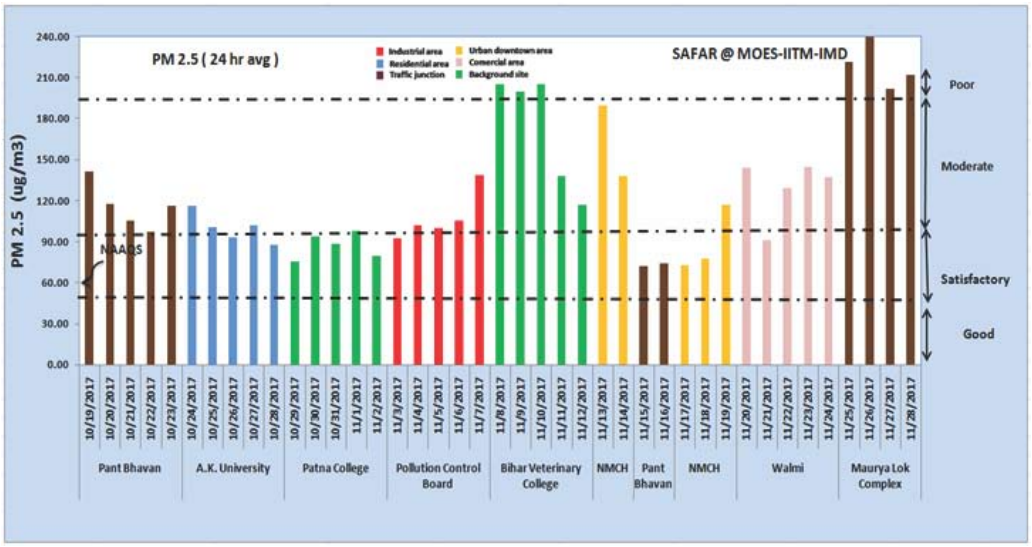


Figure 5: Daily variation in PM2.5 concentration during 19/10/2017 to 28/11/2017 at monitoring sites in Patna.

Figure 5 indicates the daily variation in PM2.5 values at each monitoring location. Maximum concentration is found at Maurya Lok complex followed by Bihar veterinary college, Walmi, Nalanda medical college and hospital, Pant Bhavan (Oct.), Pollution control board, Aryabhatta knowledge university, Patna college and the lowest at Pant Bhavan (Nov.). Levels of PM 2.5 are found above the NAAQS limit which is average 60 $\mu g/m^3$ for 24 hr. Levels in very Poor range triggers health alert for sensitive group and indicate immediate actions to reduce pollution levels. At Maurya lok complex the levels were recorded as high as 244.32 $\mu g/m^3$ which is ~ 4 times higher than the prescribed limit and falls under very poor category of AQI. At Bihar veterinary college concentration ranges between 116.62 $\mu g/m^3$ to 232.55 $\mu g/m^3$, and hence comes in very poor range of AQI.Others have concentration as, at Walmi 91.23 $\mu g/m^3$ to 144.40 $\mu g/m^3$ being in very poor range of AQI. Nalanda Medical college and Hospital has concentration ranging between 72.88 $\mu g/m^3$ to 189.61 $\mu g/m^3$. Pant Bhavan in the month of October i.e., on Diwali festive day has an concentration ranging between 97.05 $\mu g/m^3$ to 141.15 $\mu g/m^3$, while in November month it is 73.89 $\mu g/m^3$ and 71.85 $\mu g/m^3$ and hence it is seen from both the observations that in Diwali festival the concentration of PM 2.5 is high than any other normal day. This can be due to burning of fire crackers, which eventually contribute to increased levels of gaseous and fine particulate pollutants. Pollution control board, Aryabhatta knowledge university and Patna college have the concentrations ranging as follows 92.71 $\mu g/m^3$ to 138.49 $\mu g/m^3$, 87.50 $\mu g/m^3$ to 116.48 $\mu g/m^3$, 75.65 $\mu g/m^3$ to 98.24 $\mu g/m^3$ respectively.

4.1.2 Ozone (O_3)

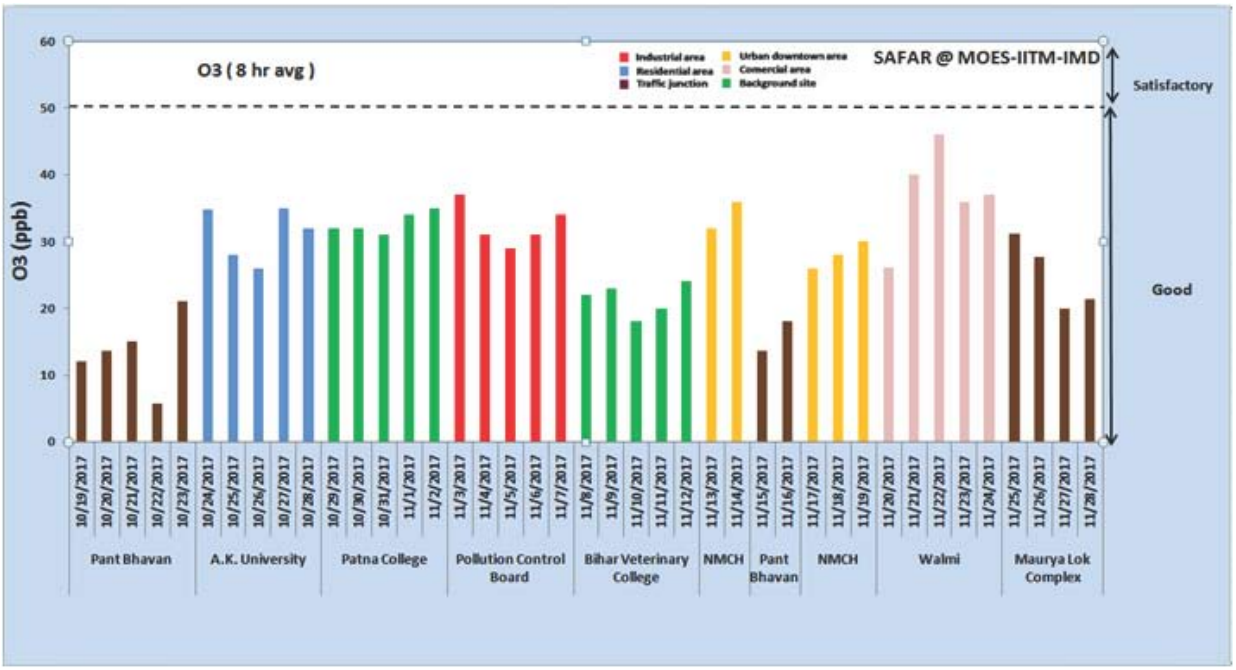


Figure 6: :Daily variation in O3 concentration during 19/10/2017 to 28/11/2017 at monitoring sites in Patna.

Figure 6 indicates the daily variation in Ozone concentration at each location. It is evident from Figure-6 that at majority of monitoring sites, volume mixing ratio of O3 is found much below the NAAQS limit of 50 ppb. From the assessment period it is seen that Walmi shows maximum 8 hr average concentration of 46ppb on 22/11/2017. Pollution control board shows 37 ppb, Nalanda medical college and hospital shows 36ppb, and Aryabhatta knowledge university shows 35 ppb.

O3 levels are found to be in “Good” range at Pant bhavan, Bihar veterinary college and Maurya lok complex, whereas in “Satisfactory” range at Aryabhatta knowledge university, Patna college, Pollution control board, Nalanda medical college and Walmi. AQI in this range indicates very little concern to sensitive group of people including children’s and elders. The minimum recorded 8 hr average was found to be 6 ppb at Pant bhavan on 22/10/2017. Ozone concentrations according to the assessed season are seemed to be sustainable for the population and are not alarming at this stage.

4.1.1.3 Nitrozen Dioxide (NO_2)

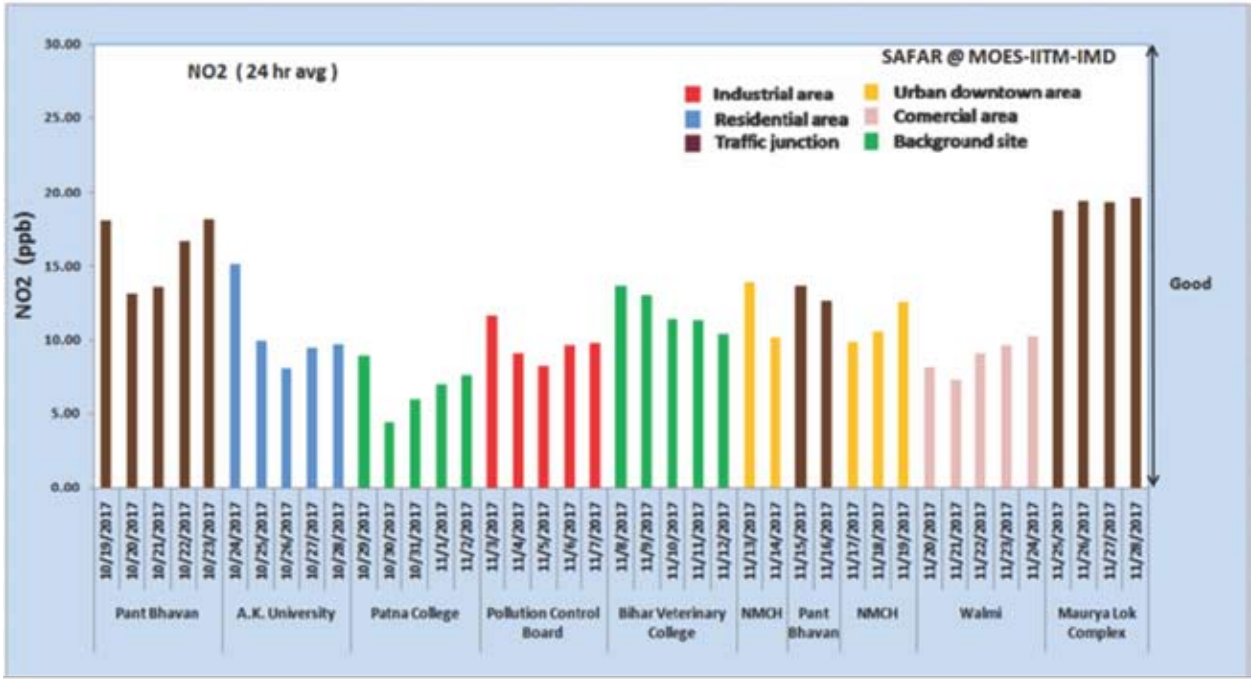


Figure 7: Daily variation in NO2 concentration during 19/10/2017 to 28/11/2017 at monitoring sites in Patna.

Figure 7 depicts daily variations in NO2 levels during 19/10/2017 to 28/11/2017. It is clearly evident from the Figure-7 that during entire study period NO2 has found well below the NAAQS limit of 43 ppb at all monitoring locations. Amongst all monitoring sites higher levels of NO2 are recorded at Maurya lok complex as 19.56 ppb and at Pant bhavan as 18.09 ppb. The lowest concentration is found at Pant bhavan as 4.41 ppb on 30/10/2017. AQIcategory for all the locations ranges in “Good” range, and hence have minimal impact on people.

4.1.4 Carbon Monoxide (CO)

Figure 8 depicts the daily volume mixing ratio of CO during 19/11/2017 to 28/11/2017. Higher mixing ratio has been recorded at Bihar veterinary college as 3 ppm on 8/11/2017. Most of the monitoring sites have been in the “Satisfactory” range of AQI with only Maurya lok complex in “Moderate” range of AQI.Maurya lok complex being an commercial/traffic area, is crowded with traffic and hence the CO concentration in the area is more than other locations, indicating little health risk to sensitive group of people. The average of values at the time of monitoring location at each location is found to be within the NAAQS limit of 1.7 ppm

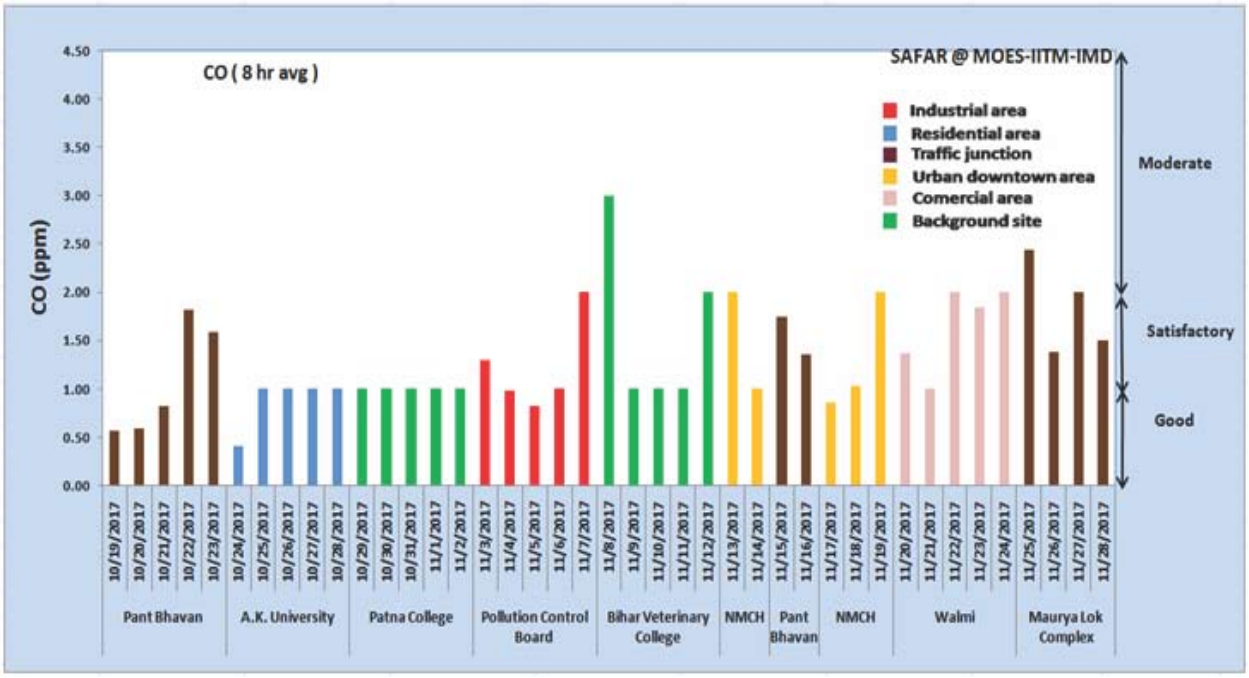


Figure 8: Daily variation in CO concentration during19-28/11/2017 at monitoring sites in Patna.

4.1.5 Sulfur Dioxide (SO_2)

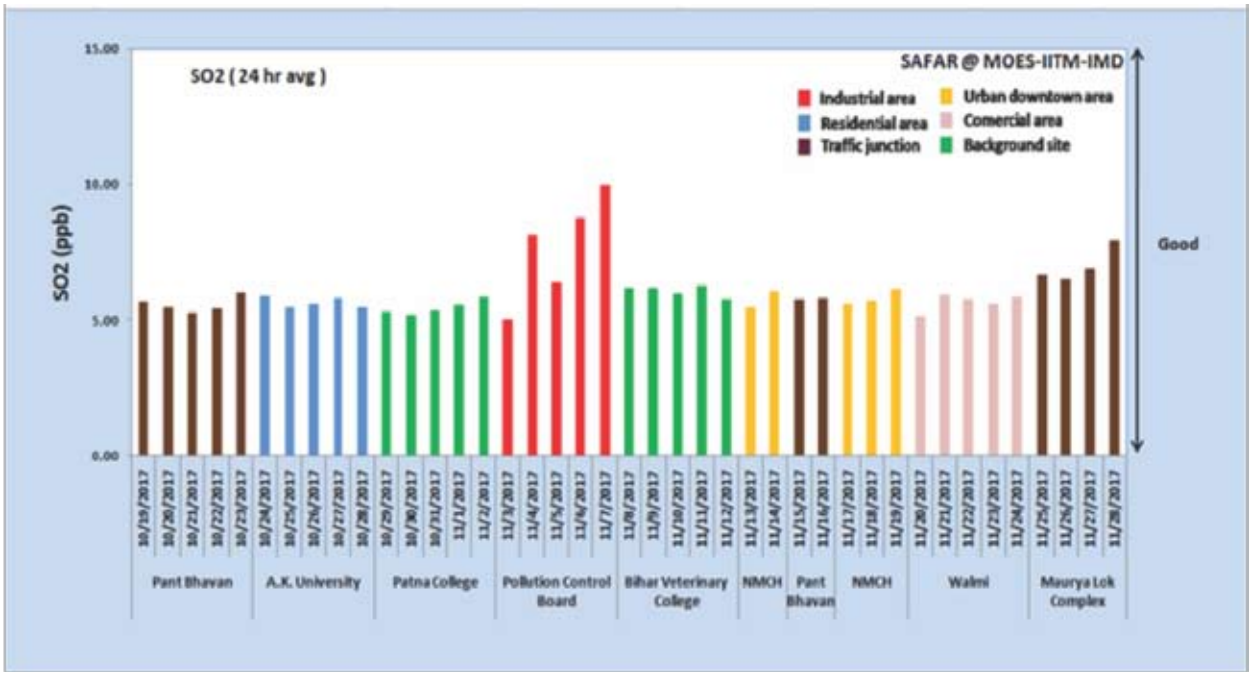


Figure 9: Daily variation in SO2 concentration during19/11/2017 to 28/11/2017 at monitoring sites in Patna.

Figure 9 depicts daily variation in SO2 during 19/11/2017 to 28/11/2017. Highest concentration has been found at Pollution control board as 9.98 ppb on 11/7/2017, it can be due to the industrial area around the location. Maurya lok complex accounts for a concentration of 7.53 ppb, Nalanda medical college and hospital has 6.14 ppb. All the values are within the NAAQS limit which is 30.53 ppb. AQI category for all the locations is in "Good" range.

4.2 Patna weather and radiation

4.2.1 UV radiation

As discussed earlier in section 3.3.2 study of levels of UV radiation in Patna city area is essential. In general UVI is found to be high during summer as compared to other seasons due to warmer temperature and high intensity of Solar Flux. The UV Index observed during the assessment period is found to be less at all locations ranging between 1.54-4.96 which indicates"No-risk" and hence there is no health risk to general public. Daily maximum value of UVI recorded at all monitoring sites during study period is shown in Figure-9 that is self-explanatory.

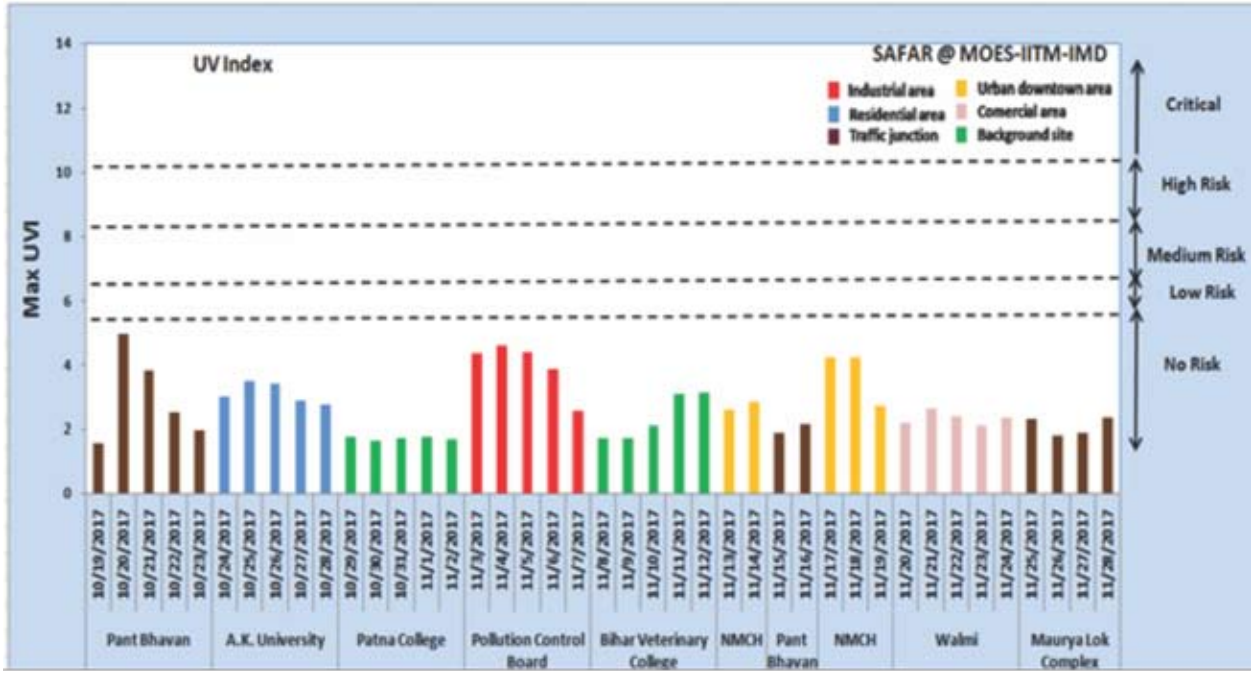
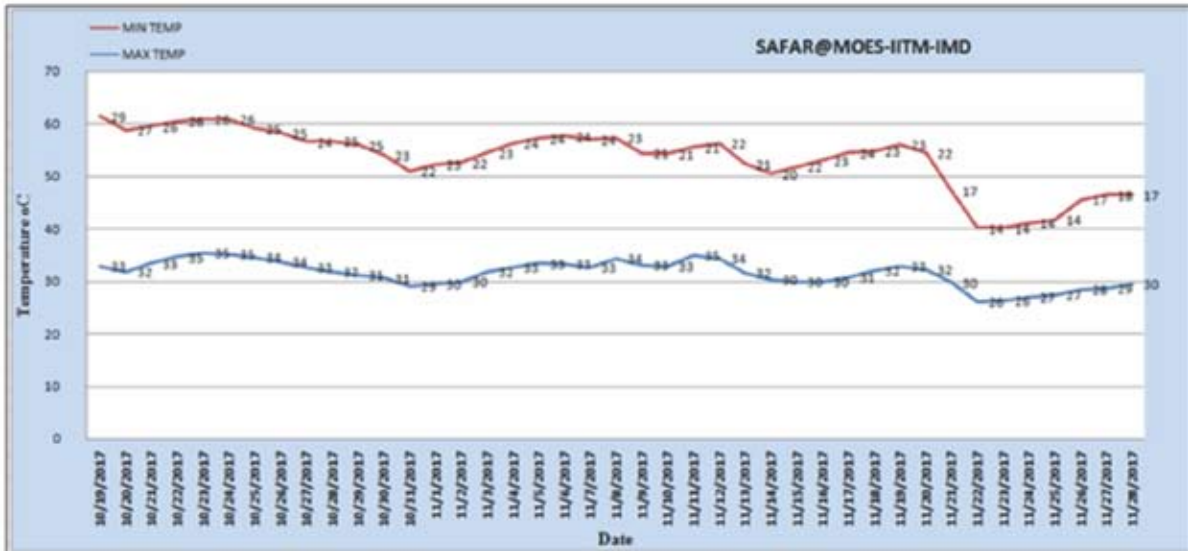


Figure 10: Daily variation in UV Index during 19/10/2017 to 28/11/2017 at different monitoring sites.

4.2.2 Meteorological Parameters



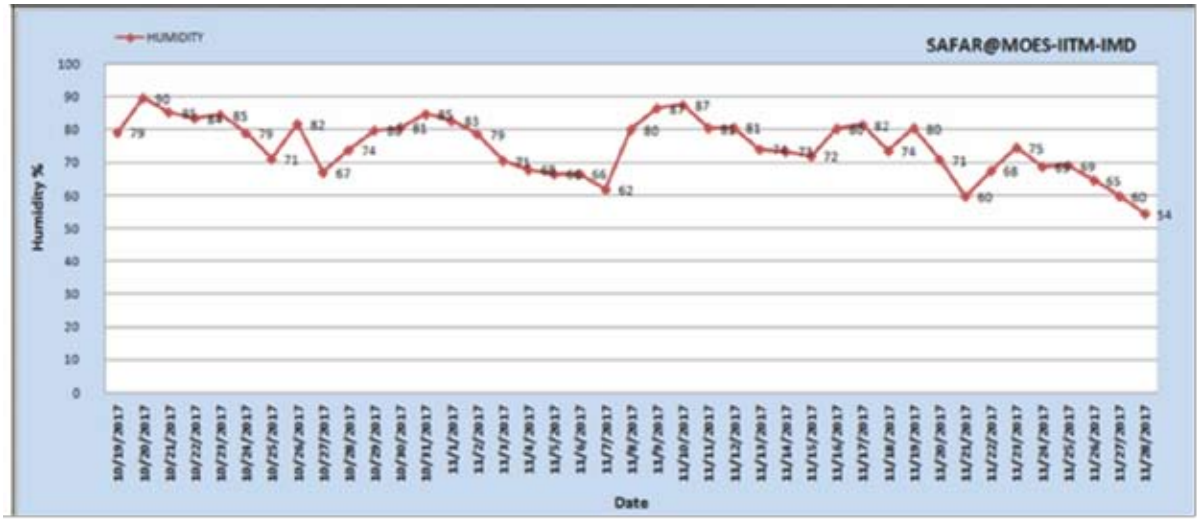


Figure 11: Daily variation in the meteorological conditions over Patna city area.
(a) Daily minimum and maximum temperature (O_C) and (b) Average Humidity(%).

(a) Shows daily minimum and maximum temperature recorded over Patna city area whereas Figure-10 (b) shows daily variations in the humidity. As monitoring is done in the month of October and November, changing trend in the temperature and humidity can clearly be seen from Figure-11. A decreasing trend in the daily minimum and maximum temperature and also in the percent humidity is observed over the region. The maximum temperature in the assessment period was observed to be 35.37oC on 23/10/2017 whereas the minimum temperaturewas observed on 23/11/2017 as 13.87oC.

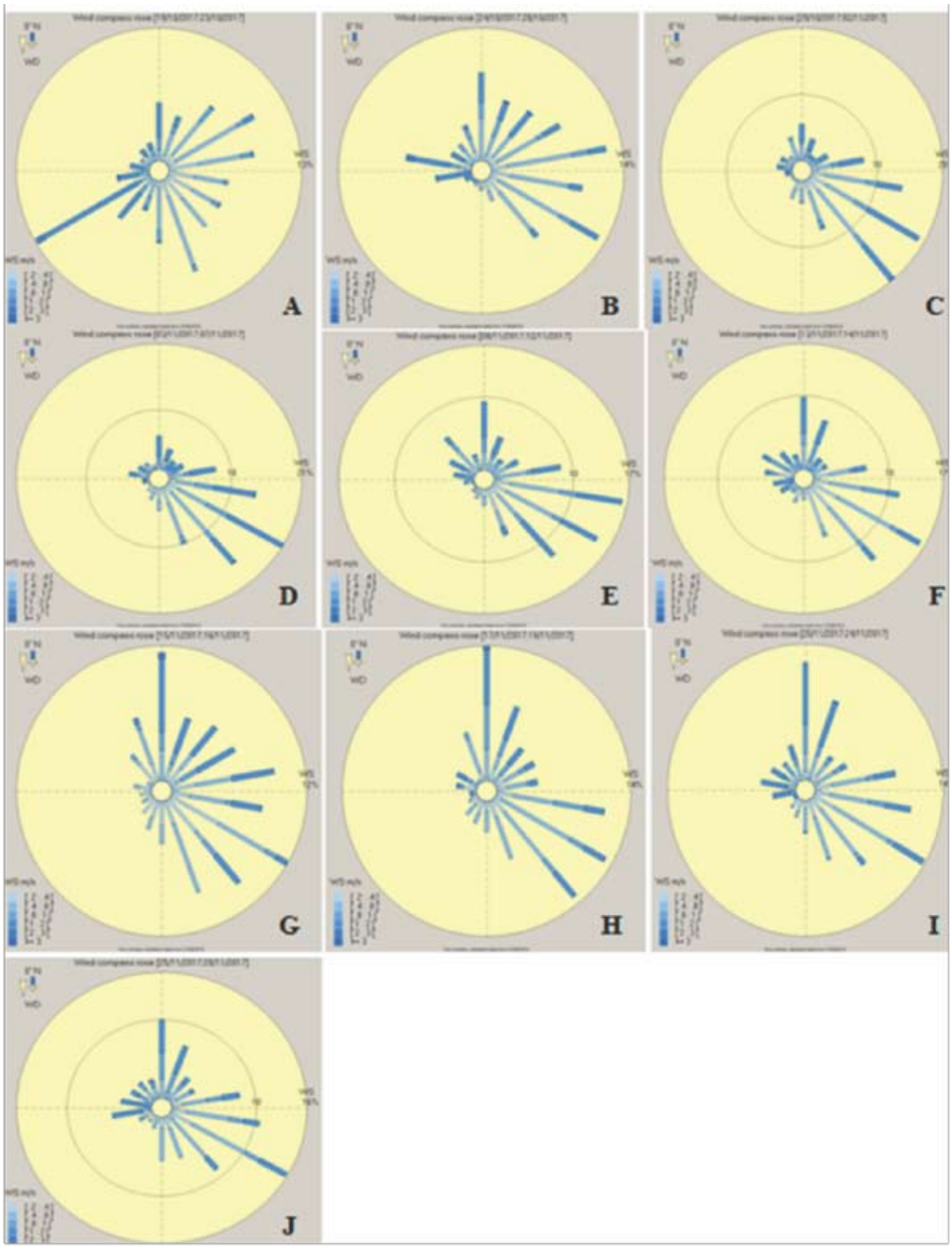


Figure 12: Wind rose diagram for each of the monitoring sites of Patna; (A) Pant Bhavan (Oct.), (B) Aryabhatta knowledge university, (C) Patna college, (D) Pollution control board, (E) Bihar veterinary college, (F) & (H) Nalanda medical college and Hospital, (G) Pant Bhavan (Nov.), (I) Walmi, (J) Maurya lok complex.

Figure- 12 shows the wind speed and wind direction at each of the monitoring site which can give us clues for pollution dispersion because of the prevailing wind direction and its speed.

The above each of the wind rosediagram is based on the monitoring period (4 to 5 days) at each of the location. These diagrams shows hourly wind data. Diagram (A) shows location Pant Bhavan in the month of October where the wind rose shows that the winds at this location and at an specified time blow from south west direction precisely from west south west (WSW) direction comprise 13% from all hourly wind directions, the speed of winds blowing from the SW direction has a speed of 3 m/s. Diagram (B) shows location Aryabhatta knowledge university where the winds are blowing from south east and east north east direction comprising of 12% from all hourly wind directions. The wind speed at this location is approximately between 2-3m/s. Diagram (C) shows location Patna college where winds are strongly blowing from south east direction comprising 20% from the all hourly wind directions, the wind speed is recorded as 3m/s. Diagram (D) shows location Pollution Control board where winds are prominently coming from south east direction typically from east south east direction comprising 21% from all hourly wind directions, wind speed for the same location is > 3m/s. Diagram (E) shows Bihar veterinary college where prominent winds are blowing from south east direction moreover from east south east direction comprising of 16% from all hourly wind directions, wind speed is 3m/s. Diagram (F) and (H) shows wind rose of location Nalanda medical college and hospital with gap of monitoring for two days, interpreting winds are blowing mostly from south east direction and in the northern direction, It comprises of about 16% and 14% from all hourly wind directions respectively. Diagram (G) shows wind rose for Pant bhavanin the month of November where winds are blowing from north and south east directions comprising 12% from south east direction and 10% from north direction from all hourly wind directions. Diagram (I) shows location Walmi, where winds are blowing from north and south east directions comprising13% from south east direction and 11% from north direction from all hourly wind directions. Diagram (J) shows location Maurya lok complex where winds are blowing from south east direction much of the time, it comprises 16% from all hourly wind directions.

5. Conclusions

Based on the observations taken during study period, the status of air quality during 19/10/2017 to 28/11/2017 is summarized in Table 7 for different individual pollutants at different locations in Patna covering all locations (micro-environments). Following conclusions can be drawn:

Gaseous Pollution: The level of NO2 (Nitrogen dioxide) in all parts of Patna is found to be well within permissible limit. Although the maximum share of NOx emissions are from transport sector that is found to be in permissible limit, but rapid increase in number of vehicle and emissions from existing old vehicles with poor maintenance remains the matter of concern. O3 (Ozone) levels are within the NAAQS limit and are not alarming. CO (Carbon monoxide) levels are in Satisfactory-Moderate range due to heavy traffic emissions. Maurya lok Complex which is an heavy traffic/ commercial site has an average of 1.8 ppm for the monitoring period and hence has an Moderate range of AQI. The concentration of CO fluctuates from 0.45 ppm to 3 ppm for an average of 24 hrs. However, the average of 5days at each location remains under the NAAQS limit for rest of the locations. SO2 levels are well within the NAAQS limit at all locations and hence remain in the 'Good' range of AQI. In conclusion, the assessment of gaseous pollutants in Patna for the monitoring period reveals that the levels are mostly within permissible limit baring a few exceptions and hence there is not an immediate alarm at this stage of time but a long term strategy need to be worked out to keep them in check before it starts to become a matter of concern.

Location	PM	PM	Ozone(O)	NO	CO	SO
Pant Bhavan(Oct.)	Moderate	Poor	Good	Good	Satisfactory	Good
Aryabhatta Knowledge University	Moderate	Poor	Satisfactory	Good	Satisfactory	Good
Patna college	Moderate	Moderate	Satisfactory	Good	Satisfactory	Good
Pollution control Board	Moderate	Poor	Satisfactory	Good	Satisfactory	Good
Bihar veterinary College	Moderate	Very Poor	Good	Good	Satisfactory	Good
Nalanda Medical college and hospital	Moderate	Poor	Satisfactory	Good	Satisfactory	Good
Walmi	Moderate	Very Poor	Satisfactory	Good	Satisfactory	Good
Maurya lok complex	Poor	Very Poor	Good	Good	Moderate	Good
Pant bhavan(Nov.)	Moderate	Moderate	Good	Good	Satisfactory	Good

Table 7: Status of air quality in Patna.

Particulate Pollution: Major air quality issue of Patna is due to particulate matters. High levels of fine particles (PM2.5 and PM10) have been observed almost at all locations. It has been observed that traffic sector contributes mainly for high concentrations of particulate pollutants. And hence locations like Maurya lok complex and Pant bhavan have concentrations more than the prescribed limit. PM10 has been found in 'Moderate' range of AQI at most of the sites with an exception of Maurya lok complex which is having 'Poor'AQI. PM2.5 is in 'Moderate to Very Poor' range of AQI, three locations are found to be in 'Very poor'range which is an alarming condition, to reduce the emissions from sources such as traffic.Most foul air quality is observed at major traffic junction where the emission from transport sector is the dominant source of pollution and hence need to be tackled.

Table 8 provides the overall summary of Air Quality Index (AQI) for each location irrespective of individual pollutant. The lead or most prominent pollutant is also mentioned. From the below table it can be noticed that Maurya lok complex which is an traffic/commercial area has a 'Very poor' air quality and AQI value as 377 due to heavy traffic emissions in that area.

Following which are Bihar veterinary college and Walmi both ranging in 'Very poor category of AQI with values as 346 and 307 respectively. This level is reported to cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases. Four of the locations viz., Nalanda Medical College and University, Pant Bhavan (Oct.), Pollution control board, and Aryabhatta Knowledge university have 'Poor' air quality with AQI values as 297,284,258 and 234 respectively. This may cause breathing discomfort to people with heart disease for short exposure. Pant Bhavan (Nov.) and Patna college are in 'Moderate' category which may cause breathing discomfort to vulnerable people having lung diseases.

Table 8: Status of overall air quality in terms of AQI of all Locations in Patna.

Location	AQI	Advisory	Lead prominent pollutant
Pant Bhavan (Nov)	142	Moderate	$PM_{2.5}$
Patna college	190	Moderate	$PM_{2.5}$
Aryabhatta Knowledge University	234	Poor	$PM_{2.5}$
Pollution Control Board	258	Poor	$PM_{2.5}$
Pant Bhavan (Oct.)	284	Poor	$PM_{2.5}$
Nalanda Medical College and University	297	Poor	$PM_{2.5}$
Walmi	307	Very poor	$PM_{2.5}$
Bihar veterinary College	346	Very poor	$PM_{2.5}$
Maurya Lok Complex	377	Very poor	$PM_{2.5}$

Although the AQI and its inferences based on Area and location provides the best assessment of air quality as it varies from one micro-environment to another but if one needs to define the single number in terms of AQI for Patna for Winter season based on current pilot project then it is calculated as AQI = 270 which falls under "Poor" category and the most prominent pollutant is found to be PM 2.5. The advisory for this category is cautionary to sensitive people having respiratory problems and heart disease, children's and elders who may experience some discomfort but on prolonged exposure normal healthy person may feel breathing discomfort and hence more precautions need to be taken in Winter season.

Overall Patna City Air Quality (ONE INDEX)	**270**	**POOR**	**PM2.5**

6. Recommendations

Air quality in any region can be improved by implementing long-term measures which may include technological advancement with proper planning, enforcement of more stringent norms to curb emissions, etc. In general, the rapid growth of vehicles, construction activity, industrial emissions, dust from paved roads, open garbage burning, use of conventional fuels such as wood, cow dung for cooking and other domestic purposes are some of the major pollution sources in Northern part of India. As per results obtained in this pilot study, authors have outlined some immediate and short-term measures and precautions to prevent adverse effects of deteriorated air quality, which are discussed in this section.

6.1 Immediate measures for individuals

If air quality in any region is in VERY POOR to SEVERE category then everyone can protect themselves from its adverse effects by following below mentioned simple steps:

- If air quality is in VERY POOR category of Air Quality Index (AQI) then people with heart or lung disease, older adults, and children are recommended to reduce prolonged or heavy exertion. If it is in SEVERE category of AQI then best remedy is to avoid all outdoor physical activities to reduce unwanted exposure levels by all category of people whether healthy or unhealthy. Everyone is recommended to avoid activities that make you breathe faster or more deeply.

- Burning biofuel like coal or wood add unwanted gaseous pollutants in to the air. In general we should avoid these kind of fuel. But, in case of air quality alerts, we should strictly adhere to no burn policy of anything substance which emits black smoke.

- The suspended dust or windblown dust is increasingly becoming a major source of particulate pollution. To avoid exposure to unwanted dust particles from suspended dust, wet mopping is highly recommended instead of conventional Jhadoo that is highly prevalent in many cities.

- In high risk areas like traffic junctions particularly the Dak Bunglow crossing in Patna where traffic remain stagnant or moves very slow due to congestion and area near polluting industries, use of proper mask is recommended.

- At a personal level, to reduce adverse effect of pollution when an alert is issued for Very poor to Severe levels, increase water intake as much as possible.

- Spending time near greener areas or in garden helps on severe warning days because pollution is likely to be at reduced level near greener areas and gardens.

- When there is a warning for Very poor to Severe AQI, it is advised to avoid early morning walk after the sunrise.

- Keep track on pollution levels in city area by following government projects or initiatives, which provide current status of air quality in your area like the mobile apps- RajVayu or SAFAR-Air which can be downloaded with simple steps in your smart mobile.

6.2 Short term measures

- Proper maintenance of vehicle is necessary
- Adopt wet sweeping to reduce emission from paved as well as unpaved roads.
- Authorities can consider covering unpaved areas on both sides of road with porous pavers blocks which can help in 2 ways- reduce the dust while traffic is passing through and also helps in quick disposal of water during rainy season.
- Focus can be given on greening unpaved roadside areas through natural or artificial grass canopy which is already found to be quite good in Patna city area. this will also help in reducing emission of windblown dust and also useful for rainwater drainage problems faced in urban areas.
- Emission from construction activities can be minimised by adopting best practices such as stabilising completed part with vegetation, stabilising earthworks with stone/soil/geotextile, use of water sprays and dust suppression, create ridges to prevent dust, compact disturbed soil, eliminate open burning, control mud and dirt trackout, reduce certain activities during windy conditions, restricting diesel exhaust emissions etc.

6.3 Long term measures

- As fossil fuel and biofuel burning is major pollution source, attempt need to be made to improve fuel quality and prevent adulteration of fuel. The emissions emitted from different fuel types used in Patna have variability. The gasoline is cleanest fuel at present followed by Petrol. The emissions emitted by burning same quantity of Diesel as compared to Petrol is 8-10 time higher. Hence, it is anybody's guess what to use and what not to use if air pollution need to be reduced.
- Another fundamental issue in our system and society is related to maintenance of vehicle. Emission from vehicles depends on age of the vehicle with particular engine condition and engine technology. Hence rigorous maintenance of old vehicles should become an integral part of our life if we use these vehicle. We must make itself realization practice and stringent compliance should remain government agenda.
- Make in India: Technological advancement to improve engine technology is the key to handle fossil fuel emissions and it is high time that we continue to strive for our own new and better technology to minimize emissions from any type of fuel. This is going to happen as nation is embarking on Make in India.
- Minimizing usage of diesel vehicle will help to improve air quality as diesel is high PM and NOx emitting fuel. To tackle it on immediate and practical manner for on road diesel vehicles, option for diesel particulate filters and other potential technology to trap tail pipe emissions should be explored.
- Improve public transport and use green fuel such as CNG/ electricity in this sector.
- Better road management with road side green cover, proper cycle paths will help to reduce emissions and also may encourage green transport.
- Improve traffic signal coordination which will allow continuous traffic flow, reduce traffic jams and idling time.

- Plant more trees as greenery act as buffer for minimizing effect of pollution.
- Recommendations focusing children's concern, Minimizing children's exposure to air pollution which includes better waste management systems and improved ventilation. Ventilation in both indoor and outdoor facilities such as schools.
- Improving child's overall health so as to reduce the further complications when the child is actually exposed to air pollution by maintaining nutrition of the children, proper exercise and vaccination at younger age.
- Better monitoring of air- Monitoring devices and systems that help individuals, parents, families, communities, and local and national government adjust to immediately prevailing conditions will help minimize exposure and will help minimize exposure and will educate the public and policymakers on key health risks. (Source:- Clean the air for children, the impact of air pollution on children, October 2016 ,UNICEF).

6.4 Role of individual in tackling air pollution problem

The problem of air pollution cannot be solved only on the basis of technological solutions or implementing more stringent norms. It can only be tackled with active participation of public in large, as each individual is responsible for determining the quality of air that we breathe.

Our personal initiatives and actions can either improve or worsen the air quality and hence the facts and figures along with remedies need to reach masses. Creating awareness about environmental issues, consequences of individual actions on the quality of air, water, soil and environmentally ethical lifestyle is the need of the hour. Billions of years are required to form this air, water, soil, forests and grasslands on which all life form depends for survival and only one haphazard action can destroy the uniqueness of nature within few hours. Therefore, one needs to value these recourses and use them sustainably without deteriorating them. Newsletters, pamphlets, newspapers, magazines, television, radios, internet, workshops, exhibitions, outdoor LED's are some of the media which can be used to create awareness and spread the message to the masses to curb the pollution problem at grass root level.

7. The Patna Declaration – 9th May 2018

Ambient air quality is a basic determinant of the quality of human life. Areal and temporal variations in air quality have been naturally dependent upon climatic and weather variations, with atmospheric motions playing an important role in balancing the atmospheric components. However, the impact of increasing human population, continued dependence of fossil fuels for myriads of economic activities, and a mismatch between technological progress and sustainability, are weakening the man-environment synergy. Resultant abnormal changes have occurred in environmental parameters, highlighted by severe air pollution hazard in our urban habitations, with disastrous consequences on human and economic health of our State.
To address the issue a National workshop on Air Pollution was organised by BSDMA in collaboration with CEECC, ADRI, on May 9, 2018 at Patna. As endorsed by the delegates and experts who attended the workshop the following 3 sets of objectives are highlighted to address the deteriorating Air Pollution scenario in Bihar and this Patna Declaration is issued accordingly:

i. Formulation of policy and plans, legal framework
ii. Enforcement of policies
iii. Awareness and education

Formulation of policy, action plans and legal framework

1. Finalization and updation in a participatory manner a time bound targets based Clean air Action Plan for Patna metropolitan area and strengthening of sectoral emission inventory (Action – BSPCB; supporting agencies BSDMA & ADRI)
2. Strengthening of institutional mechanism for monitoring and control of pollution across major cities of Bihar (Action: BSPCB).

Enforcement of policies

1. Enforcement of stringent pollution clearance certificate for vehicles and industries and use of digital platform for issuing, monitoring and managing pollution (Action – Dept of transport and BSPCB)
2. Strengthening of administrative mechanism for enforcement of conditions prescribed in Environmental clearance issued under EIA notification. (Action – SEIAA, Department of Environment and Forest, BSPCB)
3. Strengthening and implementation of an urban greening policy including vertical gardening, and promotion of urban agricultural practices (Action – Environment and Forest Dept; Municipal Corp; Dept. Of Agriculture, RCD, Bihar Bridge Construction Corporation)
4. Prohibition of open air burning of garbage and waste materials
5. Enforcement of the provisions related to the use of DG sets.

Awareness and education

1. Promotion of use of eco-friendly construction material for building and other construction and source based control measures (Action – Patna Municipal Corporation, BSPCB, BSDMA, IPRD, INGOs., NGO).
2. Promotion of provisions contained in national building code 2016 in respect for the promotion of Climate-responsive architecture by urban development department and municipalities (Action – building construction department, urban development, IPRD, NGOs, INGOs)
3. Enabling access to cleaner technologies in industries to address air pollution mitigation (Action – Department of Environment & Forests, BSPCB, IPRD).

4. Awareness generation for dust control during sweeping of roads , parks and public places etc. (Action - Department of Environment and Forest, Municipal Corporation, BSDMA, IPRD, NGOs, INGOs,

5. Encouraging investment in public transportation including promotion of e-rickshaws, efficient traffic management, promotion of active mobility (such as walking and cycling), building pedestrian lanes, use of perforated pavers and development of green belts along the roads (Action – Transport Department, BSDMA, RCD, Municipal Corporation, Department of Environment and Forest, IPRD, NGOs, INGOs)

6. Enhance capacity of primary care physicians on the respiratory, cardiometabolic and neonatal impacts of air pollution on health by integrating it in to the medical curriculum, and by providing short term training programmes for in career professionals. (Action – Health Dept, AIIMS, Patna; BSDMA)

7. Capacity building and Engagement of frontline health workers like ASHA/ANMs in raising awareness about indoor and outdoor air pollution exposures among pregnant women and lactating mothers. (Action- Health dept, Red Cross Society)

8. Awareness generation among transporters and transport workers (Transport department, BSDMA, NGOs, INGOs)

वायु प्रदूषण पर पटना घोषणा पत्र

साफ एवं स्वच्छ हवा बेहतर मानव जीवन की बुनियादी निर्धारक है। जलवायु एवं मौसम के परिवर्तन के कारण वातावरण में होने वाले अस्थायी परिवर्तनों का प्रभाव वायु की गुणवत्ता पर पड़ता है। तथापि जनसंख्या में वृद्धि का प्रभाव, बेषुमार आर्थिक गतिविधियों के लिये जीवाष्म ईंधन पर लगातार निर्भरता एवं तकनीकी प्रगति तथा उसके निरंतरता के बीच असमानता के कारण मानव तथा पर्यावरण के बीच का संबंध कमजोर पड़ता जा रहा है। इन सभी के पर्यावरण पर पड़ने वाले दुष्प्रभाव वायु प्रदूषण के रुप में शहरी जन–जीवन पर परिलक्षित हो रहे हैं जो मानव स्वास्थ्य तथा राज्य के आर्थिक स्वास्थ्य के लिए संकटपूर्ण स्थितियाँ पैदा कर रहें हैं।

उपर्युक्त के मद्देनजर बिहार राज्य आपदा प्रबंधन प्राधिकरण द्वारा CEECC (Centre of Environment Energy and Climate Change), आद्री के सहयोग से वायु प्रदूषण पर एक दिवसीय राष्ट्रीय कार्यषाला का आयोजन दिनांक 09 मई 2018 को पटना में किया गया। इस कार्यषाला में भाग लेने वाले प्रतिनिधियों तथा विषेषज्ञों द्वारा पूर्ण विचारोपरांत बिहार में वायु प्रदूषण की स्थिति से निबटने के लिए निम्नांकित तीन उद्देष्यों को दृष्टिपथ में रखकर काम करने की जरुरत को रेखांकित किया गया तथा तदनुसार यह पटना घोषणापत्र जारी किया गयाः–

1. नीतियों, योजनाओं एवं वैद्यानिक ढाँचों का निरुपण।

2. नीतियों का प्रवर्तन (Enforcement)।

3. जन–जागरुकता एवं षिक्षा।

1. नीतियों, योजनाओं एवं वैधानिक ढाँचों का निरुपण–

(i). पटना मेट्रोपोलिटन क्षेत्र में सहभागी प्रक्रिया द्वारा समयबद्ध लक्ष्य आधारित स्वच्छ वायु कार्य योजना (Clean Air Action Plan) को अंतिम रुप देना एवं अद्यतनीकरण तथा उत्सर्जन सूची का सुदृढ़ीकरण।

(कार्रवाई– बिहार राज्य प्रदूषण नियंत्रण बोर्ड**;** सहयोगी संस्थाएँः
बिहार राज्य आपदा प्रबंधन प्राधिकरण तथा आद्री)

(ii). बिहार के प्रमुख शहरों में वायु प्रदूषण पर नियंत्रण तथा अनुश्रवण के लिए संस्थागत व्यवस्था का सुदृढ़ीकरण।

(कार्रवाई– बिहार राज्य प्रदूषण नियंत्रण बोर्ड)

2. नीतियों का प्रवर्तन **(Enforcement)** –

(i). वाहनों तथा उद्योगों के लिए कठोर प्रदूषण अनापत्ति प्रमाण पत्रों का प्रवर्तन एवं प्रदूषण अनापत्ति पत्रों के निर्गमन तथा प्रदूषण के अनुश्रवण एवं प्रबंधन हेतु डिजीटल प्लेटफार्म का उपयोग करना।

(कार्रवाई– परिवहन विभाग एवं बिहार राज्य प्रदूषण
नियंत्रण बोर्ड)

(ii). EIA (Environment Impact Assessment) अधिसूचना के अन्तर्गत निर्गत प्रदूषण अनापत्ति (Environmental

Clearance) में निर्धारित शर्त्तो के अनुरुप प्रवर्तन हेतु प्रषासनिक तंत्रों का सुदृढ़ीकरण।

(कार्रवाई– **SEIAA (State Environment Impact Assessment Authority)** पर्यावरण एवं वन विभाग तथा बिहार राज्य प्रदूषण नियंत्रण बोर्ड)

(iii). लंब बागवानी (vertical gardening) सहित शहरी हरितकरण नीति का सुदृढ़ीकरण एवं कार्यान्वयन तथा शहरी कृषि कार्य को प्रोत्साहित करना।

(कार्रवाई– पर्यावरण एवं वन विभाग, नगर निगम, कृषि विभाग, पथ निर्माण विभाग, तथा बिहार राज्य पुल निर्माण निगम लि0)

(iv). खुले में कूड़ा तथा अवषिष्ट पदार्थो को जलाने पर रोक लगाना।

(कार्रवाई– पटना नगर निगम, बिहार राज्य प्रदूषण नियंत्रण बोर्ड,)

(v). डीजल जेनरेटिंग सेट के उपयोग हेतु निर्धारित नियमों का प्रवर्तन।

(कार्रवाई– पटना नगर निगम, बिहार राज्य प्रदूषण नियंत्रण बोर्ड)

3. जन–जागरुकता एवं षिक्षा –

(i). भवनों तथा अन्य निर्माण कार्यो के लिए पर्यावरण अनुकूल निर्माण सामग्रियों को व्यवहार में लाने के लिए प्रोत्साहित करना तथा ऐसे निर्माण सामग्रियों के श्रोत आधारित नियंत्रण की कार्यवाई करना।

(कार्रवाई– पटना नगर निगम, बिहार राज्य प्रदूषण नियंत्रण बोर्ड, बिहार राज्य आपदा प्रबंधन प्राधिकरण, सूचना एवं जन–सम्पर्क विभाग अन्तरराष्ट्रीय गैर सरकारी संस्थान, गैर सरकारी संस्थान)

(ii). नगर विकास विभाग तथा नगर निकायों द्वारा राष्ट्रीय भवन संहिता 2016 में जलवायु – प्रभावनीय वास्तुकला के प्रोत्साहन संबंधी प्रावधानों को लागू करना।

(कार्रवाई– भवन निर्माण विभाग, नगर विकास विभाग, सूचना एवं जन–सम्पर्क विभाग, **NGOs, INGOs**)

(iii). वायु प्रदूषण के शमन हेतु पर्यावरण को स्वच्छ करने वाले प्रौद्योगिकी उद्योगों को उपलब्ध कराना।

(कार्रवाई– पर्यावरण एवं वन विभाग, बिहार राज्य प्रदूषण नियंत्रण बोर्ड, सूचना एवं जन–सम्पर्क विभाग)

(iv). सड़कों, पार्को एवं सार्वजनिक स्थानों आदि में सफाई के दौरान धूलकणों पर नियंत्रण हेतु जन–जागरुकता।

(कार्रवाई– पर्यावरण एवं वन विभाग, नगर निगम, बिहार राज्य आपदा प्रबंधन प्राधिकरण, सूचना एवं जन सम्पर्क विभाग, **NGOs, INGOs**)

(v). ई–रिक्सा सहित सार्वजनिक परिवहन व्यवस्था के लिए निवेष को प्रोत्साहन, बेहतर यातायात प्रबंधन, पैदल और साईकिल चलाने के लिए प्रोत्साहित करना, पैदल चलने वालों के लिए अलग लेन का निर्माण, रास्ते का छिद्रीत फर्ष और सड़कों के किनारे हरित पट्टी का विकास करना।

(कार्रवाई– परिवहन विभाग, बिहार राज्य आपदा प्रबंधन प्राधिकरण, पथ निर्माण विभाग, नगर निगम, पर्यावरण एवं वन विभाग, सूचना एवं जन–सम्पर्क विभाग, **NGOs, INGOs**)

(vi). चिकित्सा के पाठ्यक्रमों में वायु प्रदूषण से हृदय रोग तथा नवजात षिषु के स्वास्थ्य पर पड़ने वाले प्रभावों को समाहित कर प्राथमिक चिकित्सकों तथा अन्य प्रोफेषनल्स का अल्पअवधि के प्रषिक्षण कार्यक्रमों के माध्यम से क्षमतावर्द्धन करना।

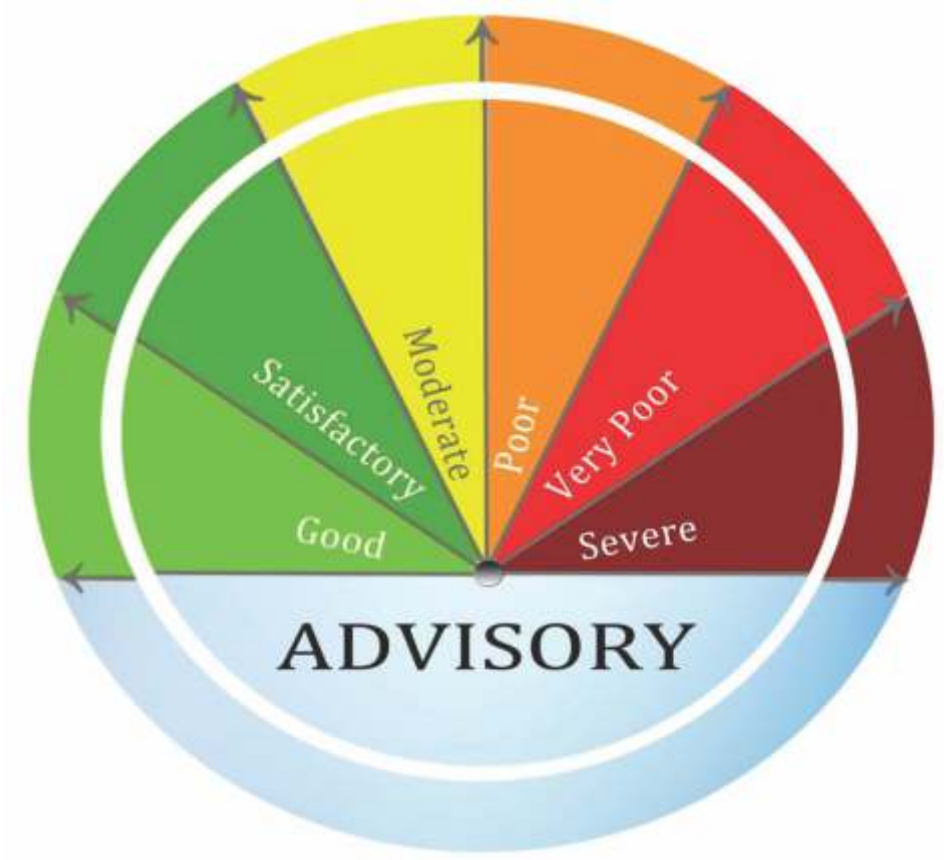
(कार्रवाई– स्वास्थ्य विभाग, **AIIMS Patna,** बिहार राज्य आपदा प्रबंधन प्राधिकरण)

(vii). गर्भवती महिलाओं तथा धात्री माताओं पर घर के अंदर और घर के बाहर पड़ने वाले वायु प्रदूषण के दुश्प्रभावों से जागरुक करने के लिए फ्रंट लाईन स्वास्थ्य कर्मी यथा ASHA/ANMs का क्षमतावर्द्धन एवं उन्हें जागरुकता के इन कार्यक्रमों में जोड़ना।

(कार्रवाई– स्वास्थ्य विभाग, रेड क्रॉस सोसाईटी)

(viii). ट्रांसपोर्टर्स और ट्रांसपोर्ट कर्मियों को वायु प्रदूषण के दुष्प्रभावों के संबंध में जागरुक करना।

(कार्रवाई– परिवहन विभाग, बिहार राज्य आपदा प्रबंधन प्राधिकरण, **NGOs, INGOs**)



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