Assessment of Ambient Air Quality of Lucknow City During Pre-Diwali, Diwali and Post-Diwali Festival

November, 2024

सीएसआईआर- भारतीय विषविज्ञान अनुसंधान संस्थान

CSIR-INDIAN INSTITUTE OF TOXICOLOGY RESEARCH

विषविज्ञान भवन, 31, महात्मा गाँधी मार्ग , लखनऊ , उ.प्र., भारत, 226001

VISHVIGYAN BHAWAN, 31, MAHATMA GANDHI MARG, LUCKNOW, 226001 U.P., INDIA

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1.1 Introduction

Diwali is one of the main festivals celebrated in India. Across the length and breadth, the country is illuminated with colorful lights and bursting of thousand tons of firecrackers for amusement during this celebration. It is celebrated with pomp and show, painting/ cleaning and lightening of houses, wearing new clothes, performing puja, exchanging sweets, greeting each other and extending good wishes, etc. It brings enthusiasm, excitement, positive energy, and harmony among the culturally different societies. During Diwali evening, all the houses across the country glitter with millions of colorful lights and other decorative items. The celebration of Diwali for five days begins on Dhanteras and ends on Bhaidooj with the reasons of traditional and mythological grounds. The festivities mainly involve the widespread use of firecrackers and increased trade activities like crowded markets and public movement releasing various pollutants into the air. Therefore, exposure to the air emissions of Diwali crackers and other sources together is detrimental to public health and affects various bodily systems, primarily respiratory and cardiovascular ailments.

The bursting of fireworks in cold weather conditions results in a sudden surge of huge quantities of various lethal toxic particles (coated with harmful metal oxides) and gases. Fireworks often contain heavy metals like lead, cadmium, and copper. These metals can have harmful health effects when inhaled or ingested, and they can persist in the environment, affecting soil and water quality. Continuous and heavy bursting of firecrackers consumes oxygen and can cause short-term sudden drops in oxygen levels in the breathing zone. Breathing in such conditions results in a shoot-up of asthma, bronchitis, respiratory and cardiovascular diseases, and emergency visits to the hospital increase by the patients suffering from respiratory diseases. Many unwanted accidents and injuries occur due to fire and firecrackers, especially to children. Also, burning firecrackers releases sulfur dioxide and nitrogen dioxide, both of which can irritate the respiratory system. Overall, the collective impact of these pollutants during Diwali can lead to a significant deterioration in air quality, posing health risks to individuals, particularly those with pre-existing respiratory conditions.

Despite the efforts to promote eco-friendly alternatives to mitigate the adverse effects on air quality, ambient air pollution levels during the Diwali period have increased suddenly more than the regular days, which signifies the influence of Diwali fireworks combustion on the atmospheric environment. Besides, the festival of Diwali also marks the beginning of the winter season with decreased atmosphere mixing height, cold weather (low temperature and high humidity), and calm wind (low wind speed < 0.5 m/s) conditions. Therefore, Diwali fireworks and other anthropogenic activities induced air emissions do not disperse easily and the pollutants accumulate near the ground level/ breathing zone.

In urban areas like Lucknow, existing local activities such as transportation, industrial, construction (buildings, road flyovers, etc.), waste burning, and cooking fuel combustion impact air quality variation temporally and spatially. On the baseline levels, the Diwali episodic activities cumulate the air pollution in the atmosphere and suddenly the air quality of the region becomes degraded as a whole. The efforts towards public awareness of air quality status due to Diwali emissions and the encouragement towards eco-friendly celebrations can mitigate the air pollution levels and its related health concerns. Therefore, the air quality survey in Lucknow city during Diwali days (i.e., pre-Diwali days, on-Diwali day, and post-Diwali days) has been carried out by CSIR-Indian Institute of Toxicology Research (CSIR-IITR) for more than two decades to present air and noise pollution impact due to Diwali festival at different locations of the city. The study delineates the additional load added to the atmospheric air pollution due to the firecrackers bursting and other festival activities in Lucknow city.

1.2 Objectives of ambient air and noise quality survey during Diwali 2024

- *to identify the ambient concentrations of particulates (PM_{10} & $PM_{2.5}$), gases (SO_2 & NO_2) pollutants and noise levels for day and night time at different sites in Lucknow*

- *to examine the status and trend of air quality over the years in Lucknow, and develop the air quality database for the Diwali period*

- *to increase public awareness about the spike in air pollution during Diwali due to the bursting of firecrackers and other festival activities in the Lucknow city.*

2.0 Monitoring Locations and Methodology:

Ambient air and noise monitoring are conducted during Diwali 2024 for particulate matter (PM_{10} & $PM_{2.5}$), gases (SO_2 & NO_2) pollutants, and noise levels at four sites in Lucknow city which are representative of two residential, and two commercial locations (Table 1 and Figure 1). The air quality monitoring is conducted during day-time (i.e., 6:00am to 6:00pm) and night-time (i.e., 6:00pm to 6:00am) for the pre-Diwali day (i.e., October 30, 2024), on Diwali day (October 31, 2024), and post-Diwali day (i.e., November 01, 2024) at all the four selected sites in Lucknow.

Table 1: Monitoring Locations

S .No.	Locations	Activities
1	Aliganj	Residential
2	Vikas Nagar	Residential
3	Aminabad	Commercial cum traffic
4	Chowk	Commercial cum traffic

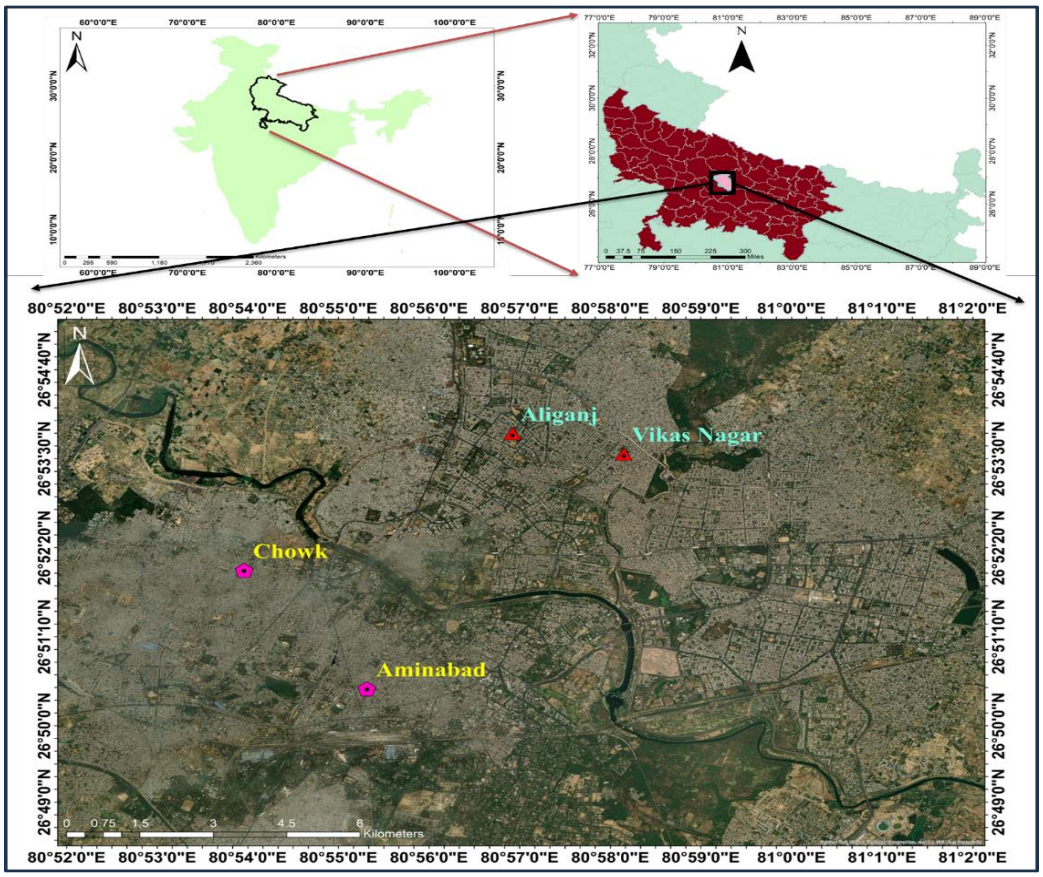


Figure 1: Ambient air and noise pollution monitoring locations in Lucknow city

3.0 Results and Discussion:

Air pollution analysis results of four monitoring sites are presented in Table 2, Figure 2, Figure 3, and Figure 4. The study identified that the reparable particulate matter monitored during pre-Diwali, on Diwali, and post-Diwali days are above the National Ambient Air Quality Standards of 60 and 100 µg/m^3 for $PM_{2.5}$ and PM_{10} respectively (Table 2).

PM_{10} Concentration during Pre-Diwali, Diwali, Post-Diwali:

Pre-Diwali (30th October 2024), the 12 hr mean concentration of PM_{10} ranged 158 to 207 µg/m^3 and average 181 µg/m^3 during day time while 185 to 253 µg/m^3 and average 217 µg/m^3 during night time.

On Diwali (31st October 2024), the 12 hr mean concentration of PM_{10} ranged 170 to 279 µg /m^3 and average 226 µg/m^3 during day time while 368 to 552 µg/m^3 and average 451 µg/m^3 during night time.

During Post-Diwali (1st November 2024), the 12 hr mean concentration of PM_{10} ranged 152 to 279 µg/m^3 and average 220 µg/m^3 during day time while 257 to 330 µg/m^3 and average 301 µg/m^3 during night time.

$PM_{2.5}$ Concentration during Pre-Diwali, Diwali, Post-Diwali:

Pre-Diwali (30th October 2024), the 12 hr mean concentration of $PM_{2.5}$ ranged 61 to 86 µg/m^3 and average 76 µg/m^3 during day time while 87 to 143 µg/m^3 and average 114 µg/m^3 during night time.

On Diwali (31st October 2024), the 12 hr mean concentration of $PM_{2.5}$ ranged 127 to 151 µg/m^3 and average 141 µg/m^3 during day time while 261 to 395 µg/m^3 and average 324 µg/m^3 during night time.

During Post-Diwali (1st November 2024), the 12 hr mean concentration of $PM_{2.5}$ ranged 89 to 135 µg/m^3 and average 112 µg/m^3 during day time while 192 to 252 µg/m^3 and average 219 µg/m^3 during night time.

On Diwali night, the level of PM_{10} had suddenly increased to 451 µg/m^3 i.e. increased by 108% from 217 µg/m^3 over the pre-Diwali night and reduced to 301 µg/m^3 during post-Diwali night (Fig.2).

On Diwali night, the level of $PM_{2.5}$ had suddenly increased to 324 µg/m^3 i.e. increased by 184% from 114 µg/m^3 over the pre-Diwali night and reduced to 219 µg/m^3 during post-Diwali night (Fig.2).

In case of SO_2, the mean level was found to be within prescribed limits. However, mean level of SO_2 on the Diwali night increased to 33 µg/m^3 i.e. increase of 50% from 22 µg/m^3 from pre-Diwali night.

The mean level of NO_2 was found to be within prescribed limits. On Diwali night the mean NO_2 value increased to 44 µg/m^3 from 33 µg/m^3 i.e. increase of 33% over the pre-Diwali night.

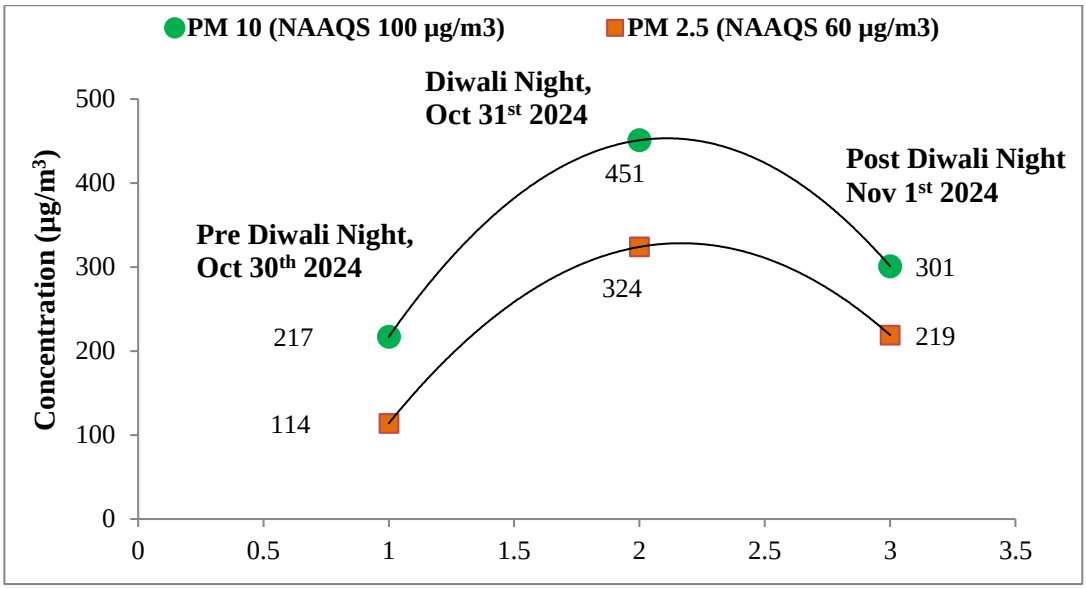


Figure 2: Profile of respirable particulates (in µg/m^3) in ambient air during the night timings of Diwali Festival

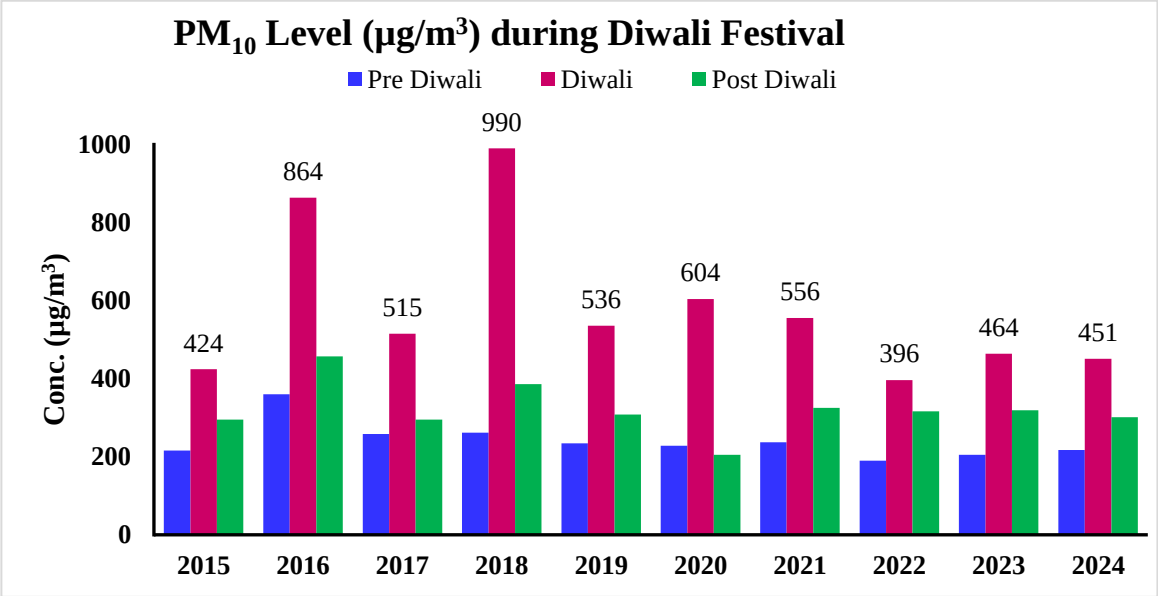
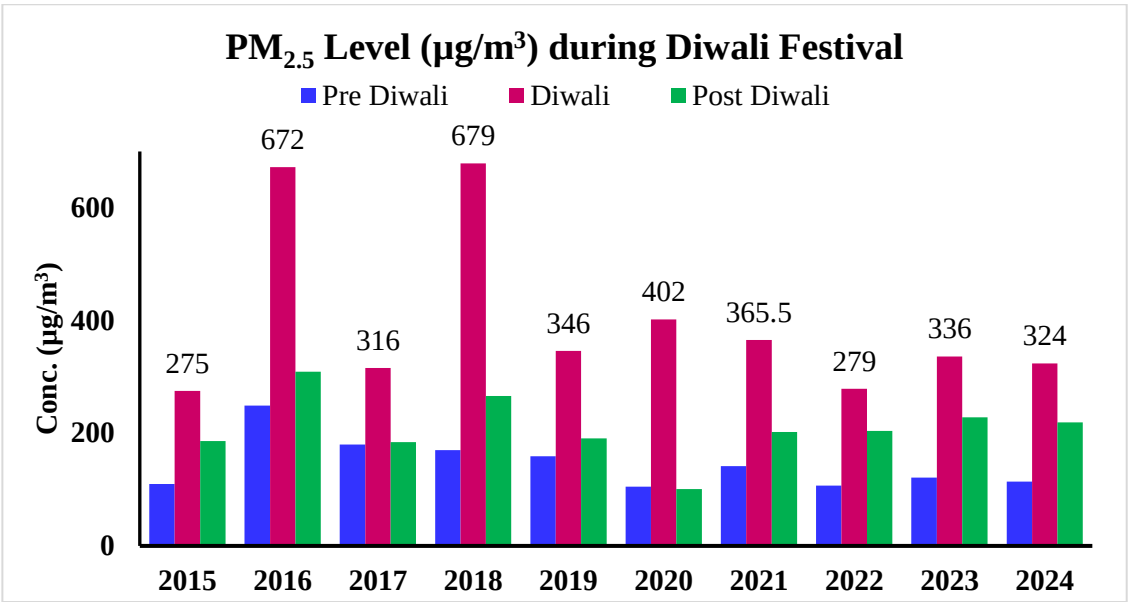


Figure 3: Levels of respirable particulates (PM_{10}) concentration during 2015, 2016, 2017, 2018 2019, 2020, 2021, 2022, 2023, and 2024 (Night time Diwali Festival)



Figuge 4: Levels of respirable fine particulates ($PM_{2.5}$) concentration during 2015, 2016, 2017, 2018 2019, 2020, 2021, 2022, 2023, and 2024 (Night time Diwali Festival)

Table 2. CSIR-IITR Diwali 2024 Pollution Survey

Locations	Pre-Diwali 2024 (October 30th 2024)		On-Diwali 2024 (October 31st 2024)		Post-Diwali 2024 (November 1st 2024)	
	Day (6:00 am to 6:00 pm)	Night (6:00 pm to 6:00 am)	Day (6:00 am to 6:00 pm)	Night (6:00 pm to 6:00 am)	Day (6:00 am to 6:00 pm)	Night (6:00 pm to 6:00 am)
Pollutant : PM_{10} ($\mu g/m^3$)						
Aliganj	161	199	183	397	192	257
Vikas Nagar	158	185	170	368	152	291
Aminabad	207	253	279	552	257	330
Chowk	198	230	272	485	279	325
Average	**181**	**217**	**226**	**451**	**220**	**301**
Pollutant : $PM_{2.5}$ ($\mu g/m^3$)						
Aliganj	61	93	127	261	89	195
Vikas Nagar	73	87	139	262	93	192
Aminabad	86	143	148	379	135	237
Chowk	85	132	151	395	130	252
Average	**76**	**114**	**141**	**324**	**112**	**219**
Pollutant : SO_2 ($\mu g/m^3$)						
Aliganj	17	20	22	27	11	23
Vikas Nagar	16	21	23	29	13	25
Aminabad	22	25	26	39	20	30
Chowk	20	23	25	38	21	29
Average	**19**	**22**	**24**	**33**	**16**	**27**
Pollutant : NO_2 ($\mu g/m^3$)						
Aliganj	26	30	29	35	27	33
Vikas Nagar	24	28	27	37	26	31
Aminabad	29	37	32	48	29	35
Chowk	28	35	34	55	31	38
Average	**27**	**33**	**31**	**44**	**28**	**34**

Noise level

The noise levels were measured at 4 locations during Pre-Diwali, Post-Diwali and On-Diwali night to assess the impact of the bursting of the fire cracker and are tabulated in **Table 3**.

The noise levels were monitored during day time between 10:00AM to 02:00PM and night time between 09:00 PM to 12:00 midnight for ~20 minutes at each location.

The highest noise level was recorded at Vikas Nagar site with 89.1 dB(A) whereas the lowest was recorded at Aminabad having value 86.9 dB(A) on Diwali night.

Firecrackers with noise level > 80 dB(A), may damage the eardrum and reduce our hearing ability. High noise can induce temporary or permanent hearing impairment.

Crackers may also trigger problems like annoyance, irritation, hypertension, stress, hearing loss, headache, sleep disturbance, and respiratory problems such as allergic bronchitis, bronchial asthma, sinusitis, rhinitis, and laryngitis.

Table 3. Noise Level in dB(A) for Pre-Diwali day, Diwali day and Post-Diwali day

Locations	Pre-Diwali (October 30, 2024)		On-Diwali (October 31, 2024)		Post- Diwali (November 01, 2024)	
	Day	Night	Day	Night	Day	Night
Aliganj	70.1	69.4	79.7	87.3	70.3	80
Vikas Nagar	72.3	69.7	80	89.1	75.1	80.3
Chowk	73.1	73.5	81.2	87.2	79.5	82.1
Aminabad	76	72.9	83.5	86.9	83.1	86

4.0 Conclusion:

During Diwali festival PM_{10}, $PM_{2.5}$ levels exceeded National Ambient Air Quality Standards (NAAQS 2009) of 100 and 60 µg/m^3 and gaseous pollutants SO_2 and NO_2 were within limits of 80 µg/m^3. Day and Night time noise levels exceeded their respective CPCB standards of residential area (day time: 55 and night time: 45 dB(A)) and commercial area (day time: 65 and night time: 55 dB(A)).

The observed levels are also influenced by human activities and meteorological conditions. During Diwali air quality campaign high level of activities particularly traffics and crowded markets have been observed till late night in addition to the cracker burning resulting in more emissions of air pollutants. Towards the October end or November beginning, winter season begins, leads to drop in temperature and low wind speed also makes favorable conditions for higher air pollutions.

On Diwali night, the level of PM_{10} had suddenly increased to 451 µg/m^3 i.e. Increased by 108 % from 217 µg/m^3 over the pre-Diwali night and reduced to 301 µg/m^3 during post-Diwali night.

On Diwali night, the level of $PM_{2.5}$ had suddenly increased to 324 µg/m^3 i.e. Increase by 185 % from 114 µg/m^3 over the pre-Diwali night and reduced to 228 µg/m^3 during post-Diwali night.

The highest noise level was recorded at Vikas Nagar site whereas the lowest was recorded at Aminabad area on Diwali night. The night time noise levels exceeded the prescribed CPCB night Standards at all locations.

The large quantity of pollutants formed due to the burning of firecrackers during the Diwali festival are the cause of the increase of air pollution in Lucknow city which may also be the cause of increased mortality and morbidity in urban areas. Individual bursting of firecrackers should be discouraged. However, alternatively, community celebration may be allowed in predefined areas.

5.0 Recommendations to Abate Air Pollution due to Diwali Fireworks

1) Air quality and noise monitoring shall be strategically planned during the Diwali festival as per Guidelines/policy to monitor air quality during the Diwali festival and provide advance warning by demonstrating the air quality index of the city.

2) Encouragement to use Green firecrackers over the conventional ones for lower air emissions.

3) Control on illegal manufacturing of traditional crackers and regulating the marketing of firecrackers.

4) Open environment / elevated spaces adjacent/ higher to residential houses/ areas shall be designed to easily disperse and dilution of pollution and designated such places for the combustion of firecrackers.

5) After the festival celebrations, all the waste material shall be disposed of properly to avoid contamination spread.

6) Strictly prohibit the burning of fireworks on roads/highways and sensitive/ silence zones.

7) Public awareness programmes during the pre-Diwali days shall be encouraged for the full festival experience without affecting the environment and public health & safety.

8) Using air purifiers, and personal masks and avoiding outing mobility during the Diwali festival can help to protect health.

Contributors:

The survey, sampling, data analysis, and report preparation are done by the following team of the Environmental Monitoring Laboratory, ASSIST Division, CSIR-IITR

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"Until all of us have succeeded, none of us have"


"सुरक्षा पर्यावरण और स्वास्थ्य
और उद्योग के लिये सेवा"
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health and service to industry"**


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- NABL (ISO/IEC 17025:2017) accredited Safety/ toxicity evaluation of NCEs
- Water quality assessment and monitoring
- Analytical services
- Environmental monitoring and impact assessment
- Information on chemicals/ products
- Computational predictive toxicity assessment

Recognitions
- Scientific & Industrial Research Organizations (SIROs)
- UP Pollution Control Board (Water & Air)
- Indian Factories Act (Drinking water)
- Bureau of Indian Standards (Synthetic detergents)
- Food Safety & Standards Authority of India (FSSAI)

Technologies Developed/ Available
- Oneer- A novel solution for safe drinking water
- Portable Water Analysis Kit
- Mobile Laboratory for environment and human health
- AO Kit for rapid screening of Argemone in mustard oil
- MO Check for detection of Butter Yellow, an adulterant, in edible oils

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- एनएबीएल (आईएसओ/आईईसी 17025:2017) मान्यता प्राप्त एनसीई की सुरक्षा/विषाक्तता मूल्यांकन
- जल गुणवत्ता मूल्यांकन और निगरानी
- विश्लेषणात्मक सेवाएं
- पर्यावरण निगरानी और प्रभाव मूल्यांकन
- रसायनों/उत्पादों के बारे में जानकारी
- कम्प्यूटेशनल भविष्य कहनेवाला विषाक्तता मूल्यांकन

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- भारतीय मानक ब्यूरो (सिंथेटिक डिटर्जेंट)
- भारतीय खाद्य सुरक्षा और मानक प्राधिकरण (पै।ए)

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- पोर्टेबल जल विश्लेषण किट
- पर्यावरण और मानव स्वास्थ्य के लिए मोबाइल प्रयोगशाला
- सरसों के तेल में आर्जीमोन की त्वरित जांच के लिए एओ किट
- मक्खन पीले रंग का पता लगाने के लिए एमओ जांच, एक मिलावटी, खाद्य तेलों में

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