SWITCH ON FOUNDATION
CELEBRATING 15 years

State of Air Quality

ODISHA

OCTOBER 2021 TO MARCH 2023

Content

LIST OF ACRONYMS

AQI- Air Quality Index

AAQMS- Ambient Air Quality Monitoring System

CPCB- Central Pollution Control Board

CO- Carbon Monoxide

CAAQM- Continuous Ambient Air Quality Monitoring

COPD- Chronic Obstructive Pulmonary Disease

CNS- Central Nervous System

CNG- Compressed Natural Gas

DG- Diesel Generators

DNA- De-oxyribo nucleic acid

DBP- Diastolic Blood Pressure

GDP- Gross Domestic Product

GBD- Global Burden of Disease

IGP- Indo Gangetic Plain

IUGR- Intrauterine growth restriction

LPG- Liquid Petroleum Gas

LBW- Low Birth Weight

NCAP- National Clean Action Plan

NAAQS- National Ambient Air Quality Standards

NAMP- National Air Monitoring Programme

OSPCB- Odisha State Pollution Control Board

PTD- Preterm Delivery

PM- Particulate Matter

PAH- Polycyclic aromatic hydrocarbons

PRANA- Portal for Regulation of Air-pollution in Non-Attainment cities

RSPM- Respirable Suspended Particulate Matter

RPM- Respirable Particulate Matter

SPM- Suspended Particulate Matter

SPCB- State Pollution Control Board

SAIL- Steel Authority of India Limited

SBP- Systolic blood pressure

TSP- Total Suspended Particle

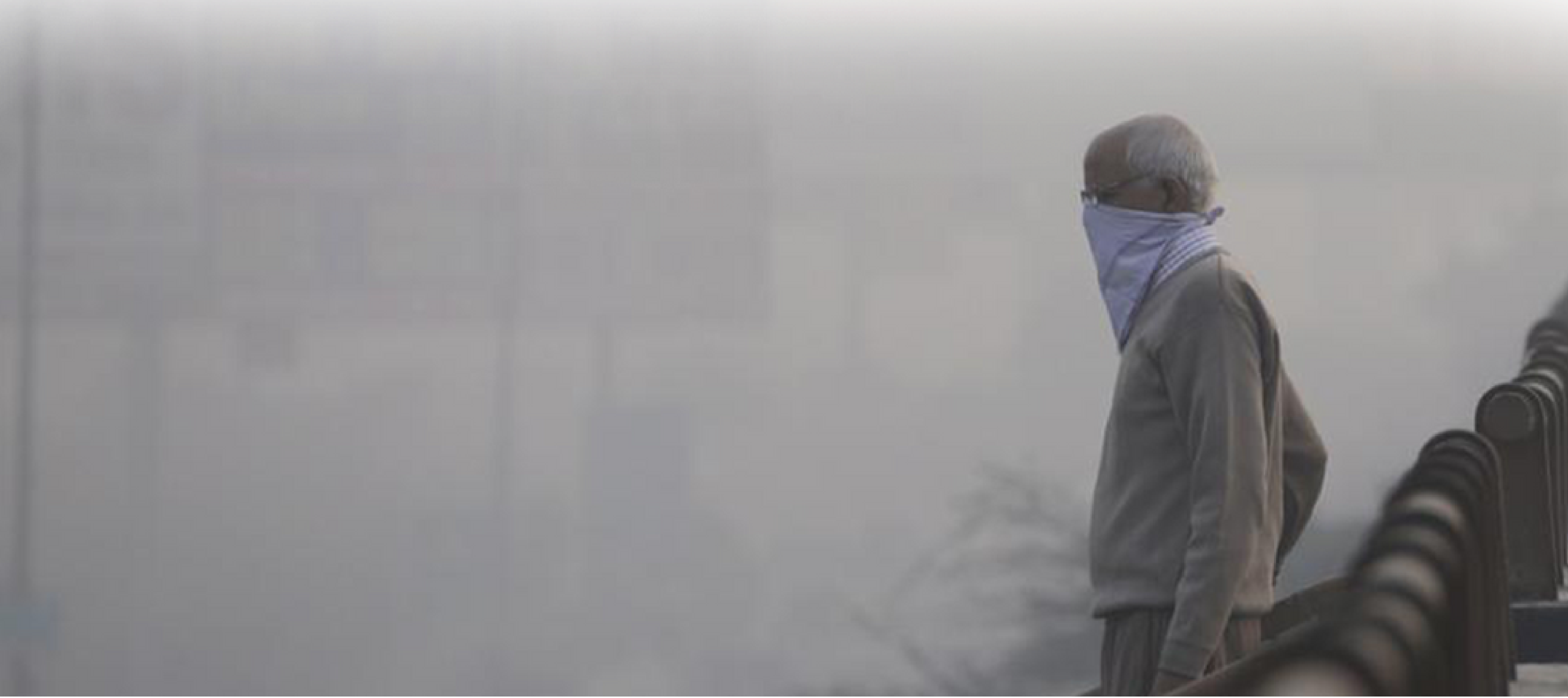
USD- US Dollars

UV- Ultraviolet

US-EPA- US-Environmental Protection Agency

VOC- Volatile Organic Compounds

XRF- X-ray fluorescence



EXECUTIVE SUMMARY

Air pollution in India is a concerning environmental issue. The Air (Prevention and Control of Pollution) Act was passed in 1981 to regulate air pollution but has failed to reduce pollution, because of poor enforcement of the rules (Mongabay-India, 2020). The goal of this act is to improve the quality of air, promote clean air and prevent pollution.

Air Quality Monitoring is an important part of air quality management. The **National Air Monitoring Programme** (NAMP) is established with the objectives to determine the present air quality status and trends, and to control and regulate pollution from industries and other sources to meet air quality standards. It also provides background air quality data needed for industrial siting and town planning.

Besides this, CPCB has an automatic monitoring station at ITO Intersection in New Delhi. At this station Respirable Suspended Particulate Matter (RSPM) (PM_{10} and $PM_{2.5}$), Carbon Monoxide (CO), Ozone (O_3), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), and Suspended Particulate Matter (SPM) are being monitored regularly. Information on Air Quality at ITO is updated every week.

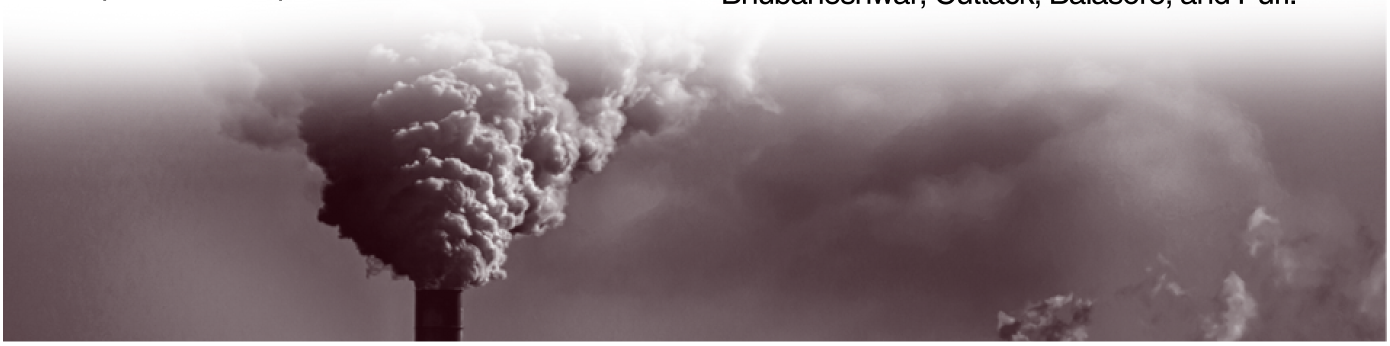
The State Pollution Control Board (SPCB), Odisha was constituted in July 1983 and was entrusted with the responsibility of implementing the Environmental Acts, particularly the Air (Prevention and Control of Pollution) Act, 1981 addressing specific environmental problems like cleaning the air and prevention of pollution.

The OSPCB also executes and ensures proper implementation of the Environmental Policies of the Union and the State Government. The activities of the OSPCB broadly cover the following: Planning comprehensive programs towards prevention, control, or abatement of pollution and enforcing the environmental laws, advising the state government on any matter concerning prevention and control of air pollution, environmental monitoring and research, and creating public awareness.

The **World Health Organisation** defines air pollution as **"the contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere"**, which simply describes how the air quality deteriorates slowly and steadily due to various agents. India is being identified as a significant victim of air pollution as 35 out of 50 (2022) most polluted cities in the world come within the boundaries of the Indian subcontinent.

Air quality data collected throughout the country by the Central Pollution Control Board (CPCB) through continuous and automatic ambient air quality monitors show high levels of Respirable Particulate Matter in the air of several Indian metro cities and also in some rural areas and semi-towns. 76% of Indians live in places that do not meet national air quality standards (Lancet Commission).

According to many existing studies on this issue, the regions with high concentrations of $PM_{2.5}$ and PM_{10} are located along the industrial belts of Rourkela, along with the urban clusters of Bhubaneshwar, Cuttack, Balasore, and Puri.



The **key findings** of this report include the following

- The monthly PM_{10} level and $PM_{2.5}$ level remained above the standard NAAQS throughout the year (2022) and rose up, particularly during the winter months of 2023.
- Multiple modes of transport, rapid industrialization, urbanization, and crowding of cities have led to the rise in levels of SPM, RPM, SO_2, NO_X, and CO in the cities of Odisha.
- Increased mortality due to particulate air pollution reflects increased pollutant emissions due to increased energy consumption, accelerated urbanization, rapid industrialization, and an increase in oil-fueled vehicles in the urban areas of the state.
- In Odisha, the major hazard to health is imposed heart diseases, lung diseases, and premature deaths due to the same.

In order to make this report useful for several stakeholders, policymakers, and more importantly for general citizens, the report guides the reader through the drivers of the problem, its present state, the existing pressures it has been creating, and the responses taken by the government to mitigate the issue. To translate the deeply researched narratives into effective and useful policies, the report also stresses on providing certain key policy suggestions along with introducing the reader to the existing policies.

Recommendations:

Following is a list of all the possible **policy recommendations** for taking immediate and holistic initiatives toward improving the air quality of the state:

1. Technological Innovations: There is a clear need to switch from environmentally exploitative technologies to cheaper and greener alternatives. Some possible technological shifts which could be adopted by various technological and scientific departments of the State can be:

- **Evolving cost-effective cleaner technologies,**
- **Adoption of clean energies: solar, wind, and hydro-powered energies,**
- **Encourage clean cooking practices using cleaner fuels such as LPG, biogas, solar, electricity, and other renewable energy sources to improve indoor air quality.**
- **Energy efficient buildings with minimum dependence on Air Conditioning; Reimagining housing structures in rural areas with efficient ventilation to maintain healthy indoor air quality:** Retrofitting these designs into already constructed houses should be considered.

2. Promoting climate-smart e-agriculture: Agriculture is a key contributor to toxic air pollutants that further degrade India's environment. India should use appropriate technology to reduce its agricultural GHG pollution- including pollution emerging from crop residue burning (CRB) and livestock- by at least 18 percent to stay on its Paris Agreement goal of emission reduction and net-zero targets. Considering that CRB accounts for 17% of PM_{10} and 16% of $PM_{2.5}$ air pollution during the winter months in India. Promoting climate-smart agriculture can turn the wheel in favour of India's mitigation plans for tackling degrading air quality.

- **Direct procurement of Agri-waste by large agro-waste management companies**
- **Incentivize and encourage farmers to explore new markets for selling crop residues for their alternative usages such as making** bedding material for animals, livestock feed, soil mulching, bio-gas generation, bio-manure/compost, thatching for rural homes, mushroom cultivation, biomass energy production, fuel for domestic and industrial use.
- **Encourage an interstate paddy stubble trading model –** for example, paddy stubble generated in the fields of Odisha can be collected and processed in OFPOs and can be traded to northeastern states where the stubble can be used for edible mushroom cultivation.
- **Encourage the selling of agri-waste in exchange for fodder for livestock holders.**
- **Innovate technologies that shred paddy markets and convert them into fodder for cattle.**
- **Incentivize climate-smart agricultural models.**
- **The government should introduce Payment for Ecosystem Services (PES) for farmers to abstain from CRB and practice sustainable agriculture.**

3. Preparation of afforestation and green cover plans: As per the Department of Environment, Government of Odisha, about 33% of Odisha's total geographical area is under forest cover, being a rich biodiversity hotspot. Forest fires are a large source of PM pollution apart from harming a rich floral and faunal diversity.

Odisha has also seen a significant reduction in the urban green cover with the rampant felling of trees to widen roads and the covering of wetlands and marshes to bring real estate projects. Some of the possible policies which can be adopted to make the state's ULB's green are:

- **Undertaking reforestation and afforestation drives along roadsides and medians:** It is necessary to ensure proper maintenance and sustainability of these green covers. This is recommended because Odisha gets rampaged by severe super-cyclones every monsoon. The government should provide replantation soon after. This can be done in collaboration with PWD and the National Highway Authority of India (NHAI). Some other strategies include:
- **Covering landfills with vegetation,**
- **Vertical gardens on pillars can be encouraged especially on the pillars of over bridges and flyovers,**
- **Relocation of brick kilns further away from the cities,**
- **Recovering wetlands,**
- **Desilting of drains.**

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4. Sustainable Urban Mobility: Being a mass contributor to GHGs in the cities, there is an urgent need to curb vehicular emissions and phase out diesel vehicles by 2025. Following are some policy recommendations to rethink urban mobility:

- **Promote bicycle lanes, cycling, and non-motorized transport.**
- **Increase distribution of electric and hybrid vehicles.**
- **Encourage electric two/three wheelers.**
- **Timely technical checking of traffic lights.**
- **Boost last-mile connectivity through clean/ e-Rickshaws.**
- **Issue guidelines for vehicle ownership and usage.**
- **Mandatory scrapping of very old vehicles.**
- **Third-party evaluation and certification of the transport systems need to be adopted.**

5. Stringent Planning and Implementation: Action to mitigate air quality requires stringent action plans at the national and sub-national levels coupled with efficient monitoring mechanisms. State governments and Boards should enlist immediate tasks as well as future tasks based on priorities and emission goals, inform policymakers at the state and regional levels, and implement interventions to curb air pollution in the polluted parts of the city. This would ensure a comprehensive approach to building more sustainable solutions.

6. Industrial planning: Industries are one of the major contributors to toxic chemical pollutants. Hence, industrial planning in mitigating air pollution should adopt a three-tier approach that takes into account the **revision of emission standards and practices, improve the audit process,** and an **accuracy-based bonus payment** system to **incentivize industrial law enforcement.** Some of the other best practices already adopted in first-world countries can also be replicated in the most polluted metropolitan areas of the nation.

- **Encourage the 'polluters pay' principle for highly pollutive industries after EIA to prevent, limit or enforce strict liability for these industries.**
- **Encourage emission trading system, also known as 'cap and trade' system:** In this system, to incentivize firms to reduce their emissions, a government sets a cap on the maximum levels of emissions and creates permits and allowances, for each unit of emissions allowed under the cap. The currency of trade would be the tonnage of pollutants produced such as CO_2 , NO_x and SO_x units.

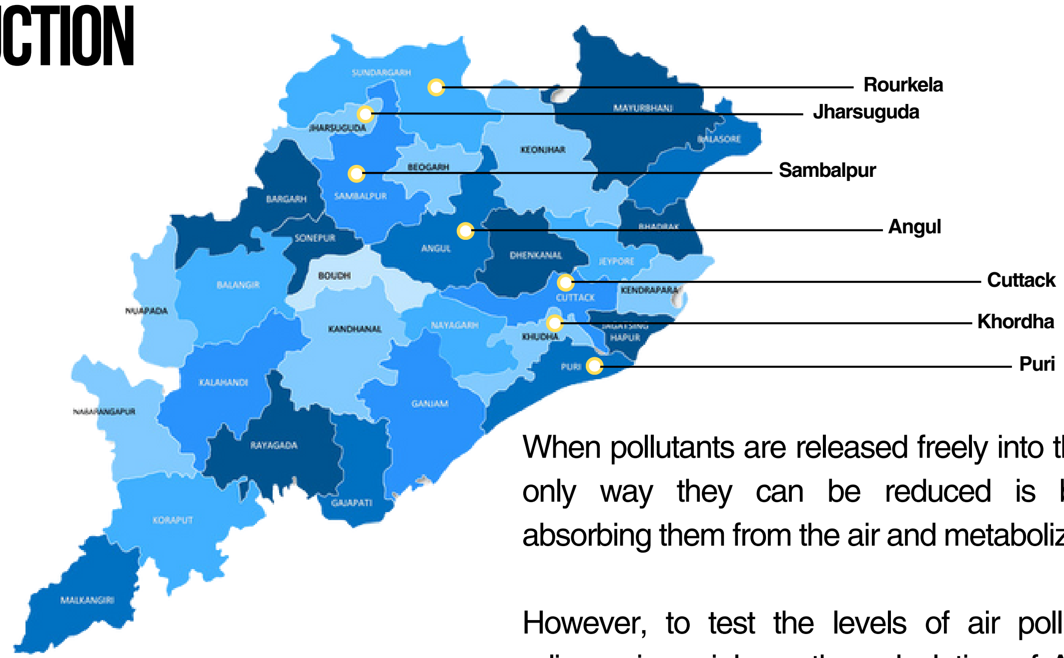
7.Waste Management: The connection between landfill emissions- composed of carbon monoxide (CO), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), particulate matter (PM), and hydrocarbons (HC)- and large-scale open waste disposal grounds has been established by several researchers. **States** should **follow an integrated waste management system (IWM) to reduce methane and carbon dioxide released from landfills by decomposing organic waste dumped into these waste disposal grounds.** Active promotion of the 5 R's (reduce, reuse, refuse, recycle, and repurpose), along with awareness among the citizens, is necessary for the reduction of waste generation in the state.

8. Data Management and Data Sharing: Currently, Odisha has a total of 35 monitors, however, OSPCB website captures air quality data on a timely basis from 33 monitors. Therefore, there is an urgent need for the state to install a greater number of monitors, especially in the sites which act as pollution hotspots for the state. **Air Quality monitors should also be installed in the entire stretch of the wetlands and the major landfill sites, as the wetlands act as a major carbon sink for the city, therefore tracking the quality of air around the city would provide an important database for other departments of the state to formulate policies around it.** Similarly, there are a lot of third-party private organizations that monitor the quality of air across the State using highly accurate monitors, with whom opportunities for partnership, data, and knowledge sharing should be sought. Air pollution abatement plans should largely be driven by what the data speak and hence the state should prioritize managing highly accurate and consistent air quality data.

9. Creating Public Awareness and Citizen-focused Policies: Generating public awareness and liaising with informed citizen bodies, CSOs, and NGOs through sustainable behavioral shifts is key to driving change when formulating policies in mitigating air pollution. All stakeholders must be aware of the severe health impacts of air pollution and hence the state health departments should push forward to coming up with health advisories before the onset of winter, as those are the months when the state experiences the worst air quality. Stakeholder-specific awareness campaigns should be organized to inform citizens about environmentally sound practices, sustainable living, and waste management at source, and encourage compositing and indoor plantation activities. These drives would ensure that all participants are aware of the impacts of air pollution and the repercussions of pollution-causing actions.

Last but not least, air pollution is largely an anthropogenic problem. Hence, all policies advocated at national, sub-national, or regional levels must ensure that they are in conjunction with citizens' livelihoods and choices. Like behavioral shifts can be one way of addressing it, it is also important to understand the policies should be largely attainable and implemented so that citizens are able to abide by it. Similarly, for the smooth implementation of these policies, systems of checks and rewards should also be adopted simultaneously to ensure any non-adherence to air pollution laws is dealt with appropriate penalties and likewise the good practices and behaviour among citizens are incentivized or rewarded.

INTRODUCTION



Odisha has attracted more industries in the last two decades, because of its convenient location and the motivational approach of the government towards the industrial revolution. The pace of industrialization in the last decades in this area has led to population surges, urbanization, and other related developments, bringing environmental impacts closer to the limits of the tolerance threshold. Severely polluted industrial areas/clusters are not only environmental challenges but also public health challenges.

Although these heavily polluted areas pose a major threat to the environment and public health, so far, only a small number of national/international efforts have been made to curb the pollution level in these areas. Of late this has forced people to realize that it is necessary to develop an objective method to quantify the environmental conditions in the industrial clusters. Though all Indian industries function by following the rules and regulations of the **Central Pollution Control Board (CPCB)**, the pollution situation is still dissatisfactory.

No mechanical or chemical instrument can completely analyze pollutant emissions at the source.

When pollutants are released freely into the air, the only way they can be reduced is by plants absorbing them from the air and metabolizing them.

However, to test the levels of air pollution, the reliance is mainly on the calculation of AQI or the Air Quality Index. In today's world of technology and science, there is a real-time calculator of AQI available where one can get a simplified calculation of the quality of the air we breathe in, on a scale of **"Good"** to **"Hazardous"** (World Air Quality Index Project).

Air pollution haunts our outdoor as well as indoor air, being the **"silent killer"**. It fluctuates with seasons, rising during the winter months and reducing significantly during monsoon. Similarly, a dip in the pollution level is observed during the pandemic, when there existed severe restrictions on vehicular mobility. Air pollution is one of the world's leading causes of death, with various effects, killing approximately 4.2 million people worldwide each year (https://www.who. int).

The AQI dropped rapidly during the global lockdown of Covid-19 and even post the tragedy. The level of pollution is subjective to rural and urban cities. On a broader spectrum, studies in India reported a decrease in aerosols, NO_x, SO_x, CO, CO_2 .and an increase in surface ozone (O_3) during lockdown periods (percentages vary by pollutant and city), the benefits of a cleaner environment due to the lockdown was advocated (Paital, 2020).

In order to combat the growing air pollution, **NCAP (National Clean Action Plan)** is put into action in 2018, under which all Indian cities have to meet the **NAAQS (National Ambient Air Quality Standards)** and the cities that fail to comply are tagged as **"non-attainment" cities.**

Out of India's most polluted states, Odisha is in the 4th position with seven of its cities categorized under the "Non-attainment" zone, namely **Bhubaneswar, Cuttack, Balasore, Angul, Rourkela, Kalinganagar,** and **Talcher** (OSPCB).

OBJECTIVES OF THE REPORT

This report aims to cater to a plethora of stakeholders such as government bodies, non-governmental organizations, medical professionals, civil society organizations, youths, and all the citizens of Odisha who understand the magnitude of this pressing problem of environmental pollution and are willing to take action to control the rising air pollution. The primary objectives of this report are-

- To examine the state of air quality in Odisha,
- To identify the sources affecting air pollution and the underlying factors,
- To highlight the seasonal variations with respect to the quality of air,
- To study the air quality levels during covid and post-covid, and
- To study the health hazards of ambient air pollution.

NCAP status for Odisha

NCAP plans:

National Clean Air Programme (NCAP) is India's flagship programme for better air quality in 122 cities, launched in 2019. NCAP is focused on non-attainment cities in India as they did not meet the national ambient air quality standards (NAAQS) for the period of 2011-15 under the National Air Quality Monitoring Program (NAMP).

NCAP Key Priorities:

- Each city under NCAP had developed its Action Plan to meet the targets. These could be understood based on the following key priorities:
- Monitoring AQI - NCAP focuses on Monitoring and understanding of air pollution/emission and its sources led by the PCB's.
- Action to Clean-up Pollution - Cities have taken steps to address the problem once the source has emitted the pollution/emission.
- Mitigating Air Pollution - Cities undertaking steps to ensure elimination of pollution/emission at the source.
- Public Engagement and Awareness - Action undertaken with the objective of engaging the public and creating awareness.

Targets

The NCAP has set a target of reducing key air pollutants PM_{10} and $PM_{2.5}$ (ultra-fine particulate matter) by 20-30% in 2024 taking the pollution levels in 2017 as the base year to improve upon. This is an interim target as the reduction needed to meet air quality standards in many cities is more than 30%.

Implementations Status:

The NCAP has set a target of reducing key air pollutants PM_{10} and $PM_{2.5}$ (ultra-fine particulate matter) by 20-30% in 2024 taking the pollution levels in 2017 as the base year to improve upon. This is an interim target as the reduction needed to meet air quality standards in many cities is more than 30%.

Odisha

Balasore	Source Apportionment / Emission Inventory Study is under MoU stage.The city action plan has been approved.
Kalinga Nagar	Source Apportionment / Emission Inventory Study is work under progress. The city action plan has been approved.
Rourkela	Source Apportionment / Emission Inventory Study is work under progress. The city action plan has been approved.
Talcher	Source Apportionment / Emission Inventory Study is work under progress. The city action plan has been approved.
Angul	No separate app has been developed and PGS can be addressed on the PCB site itself. (http://ospcboard.org/complaint/)Source Apportionment / Emission Inventory Studies is work under progress.GRAP has been developed City clean air action plan has been approved.
Bhubaneswar	Source Apportionment / Emission Inventory Study is work under progress. The city action plan has been approved.
Cuttack	Source Apportionment / Emission Inventory Study is work under progress. The city action plan has been approved.

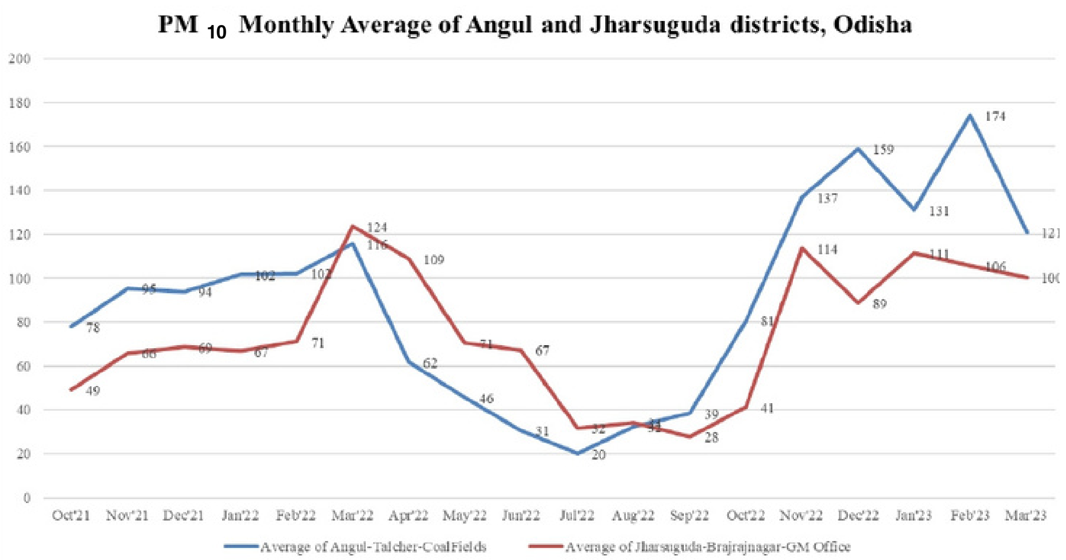
Budget :

Odisha	Fund Released
Balasore	₹0.82 Cr
Kalinga Nagar	₹3 Cr
Rourkela	₹1.2 Cr
Talcher	₹1.42 Cr
Angul	₹1.42 Cr
Bhubaneswar	₹9.42 Cr
Cuttack	₹9.42 Cr

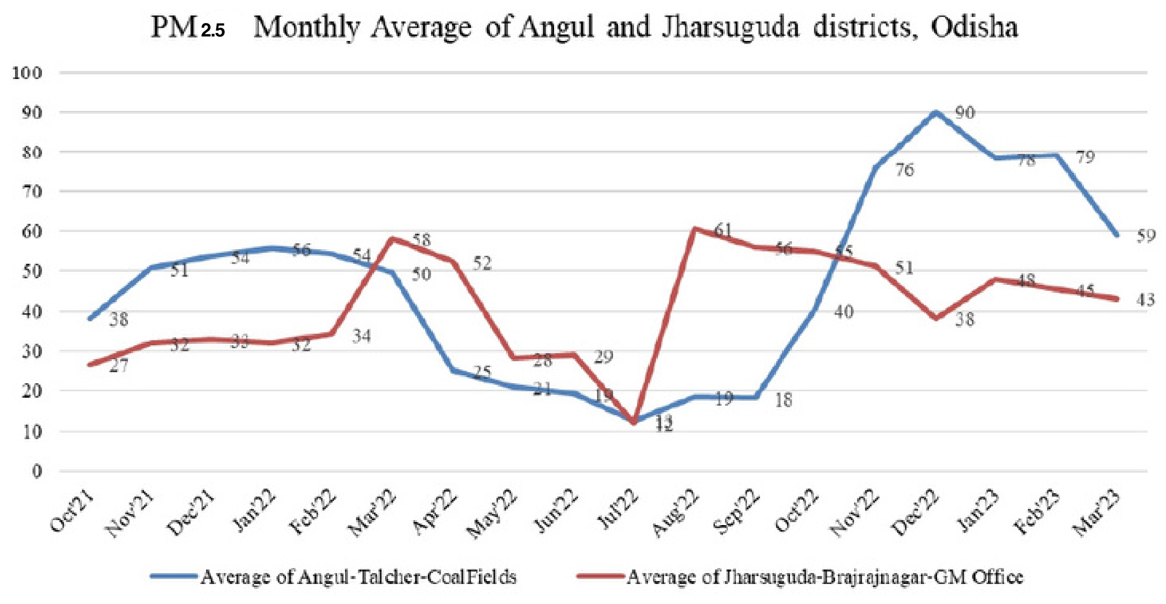
ANALYSIS OF AIR POLLUTION DATA

The following sections will shed light on the air pollution of Odisha from different perspectives. As mentioned the main pollutant considered for this analysis are $PM_{2.5}$ and PM_{10} .

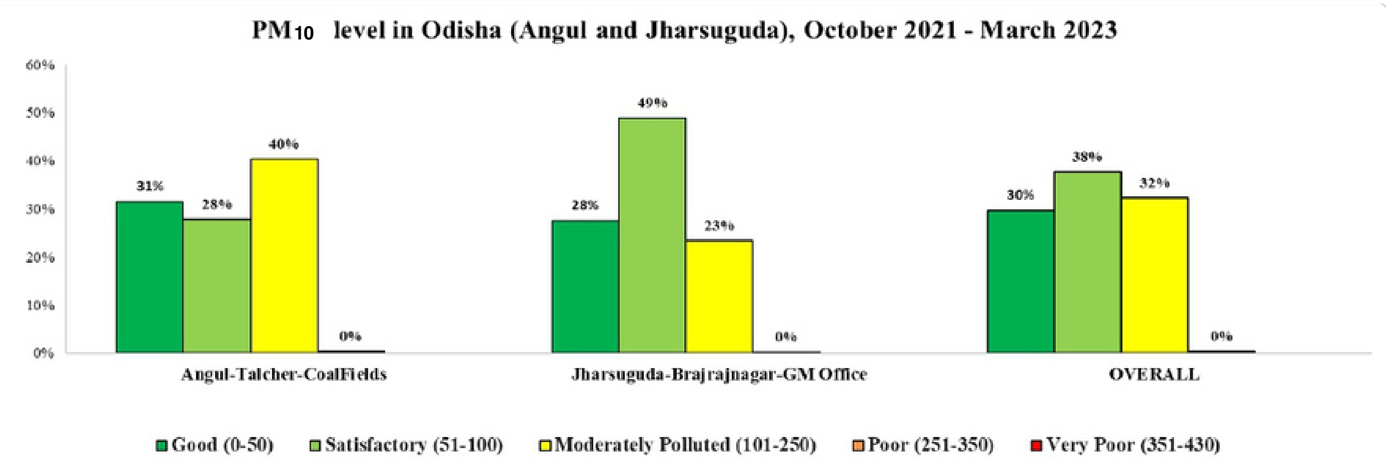
$PM_{2.5}$ and PM_{10} levels in Angul and Jharsuguda districts of Odisha (October 2021 to March 2023)



The PM_{10} in the study location is seen to peak during the winter months of 2021-22, and after a dip, it has again peaked in the winters of 2022-23.

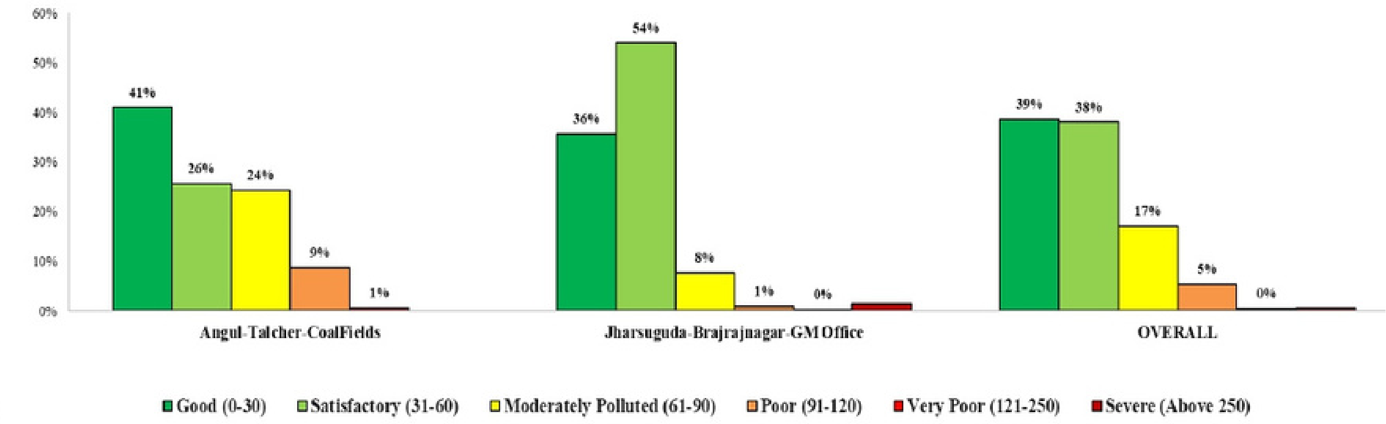


In the above graphs, the red and blue lines show the maximum monthly PM $_{2.5}$ and PM $_{10}$ levels in the Angul and Jharsuguda districts of Odisha. The air quality is seen to improve during the monsoon season, and worse during the winter season.



The bar graph above shows the PM$_{10}$ level in the districts of Angul and Jharsuguda from October 2021 to March 2023. The majority of the days have satisfactory to good quality air, throughout the year. The pollution level is seen to shoot up during the winter months, in particular.

PM 2.5 Level in Odisha (Angul and Jharsuguda), October 21-March 23



The above graphical representation depicts $PM_{2.5}$ levels in the districts of Angul and Jharsuguda from October 2021 to March 2023. Similar to that of PM_{10}, the pollution level of $PM_{2.5}$ is good or satisfactory for most of the days of the time period.

FACTORS AFFECTING AIR POLLUTION :

The major causes of air pollution in India are **motor vehicles, industries, household combustion devices, and forest fires.** Pollution caused by DG sets, brick kilns, and stone crushers are more specific to Odisha (OSPCB). Air pollutants that threaten the health of humans are Carbon monoxide, Sulphur dioxide, Nitrogen oxide, Volatile Organic Compounds (VOC), and particulate matter ($PM_{2.5}$ and PM_{10}) (WHO).

Vehicular emissions in developed countries have been significantly reduced due to improvements in the hydrocarbon emissions of vehicle components and fuels. However, the same cannot be said for developing countries. Many old and poorly maintained cars run on the road with inferior fuel.

Transportation involving the burning of diesel and gasoline in automobiles is recognized locally and internationally as a source of high levels of air pollution. Automobiles emit a large number of exhaust gasses, contributing 60-70% of air pollution found in cities (AQI, 2022).

A report by the **Blacksmith Institute of the U.S**. ranked **Odisha as the fourth most polluted state in the world** (Blacksmith Institute of the US, 2007). This high level of degradation has resulted from over 70 years of extensive mineral resource exploitation from 12 open pit mines in the area. Air pollutants are hitting seven cities in Odisha at alarming rates due to increased vehicle movement, industrial activity, and other sources of pollution.

According to **AQI (Air Quality Index)**, particulate matter (PM) less than 10 micrometres in diameter (PM_{10}) is classified as good on a scale of 0-50, with 50-100 being sufficient. Anything over 100 is treated as **"medium"**.

In 2020, the average annual air quality (PM_{10} component) was 86 in Rourkela, 108 in Kalinganagar, 92 in Talcher, 82 in Bhubaneswar, 86 in Angul, 101 in Cuttack, and 78 in Balasore. In 2021, air pollution increased in almost all of these cities. PM_{10} was 116 in Kalinganagar, 117 in Rourkela, 105 in Talcher, 95 in Angul, 76 in Balasore, 103 in Bhubaneswar, and 90 in Cuttack (Argus news, 2021).

There are social, economic, and cultural factors that get affected due to the unnerving rise in air pollution in East India. A new analysis in 2022 (Gupta, 2022) indicates that **air pollution costs Indian businesses an alarming $95 billion due to reduced productivity, work absences, and premature deaths** (The Silent Pandemic, 2019)

Economic factors:

Every fiscal year, air pollution costs about USD 95 billion, which is around 3% of India's total GDP. Premature deaths and morbidity due to rising air pollution led to an economic loss of 1.4% of India's GDP in 2019 (USD 36.8 billion). The loss was higher in the northern and central states of India (2022).

The burden of deaths, diseases, and hampering health of the working class poses a substantial adverse economic impact and an impending failure of India's aspiration to be a $5 trillion economy by 2024 (Global Burden of Disease Study, 2019).

Global Burden of Disease (GBD) study estimates that both outdoor and indoor air pollution, combined cause 5.5 million premature deaths globally, further affecting human health, particularly cardiovascular and respiratory diseases. It also affects agriculture with impacts on the ecosystem and biodiversity. India being an agricultural economy contributes to about 21% of the total GDP every year. The effect of air pollution on crop fields will hit the economy tremendously.

Increasing economic activities lead to a high energy demand which will accelerate the release of atmospheric pollutants to a great extent. With the lack of stringent policies to keep the rise in check, global emissions will significantly increase, adversely affecting the economy like a vicious circle of events.

According to a report, the annual cost of combating health issues caused due to air pollution reaches up to USD 21 billion. By 2060, the number of labour working days affecting labour productivity is expected to reach 3.7 billion per year, if not monitored or acted upon soon (Policy Highlights, 2021).

The following are the major reasons behind a faltering economy due to pollution,

- **Productivity cost of absenteeism-** India lost around 1.3 billion working days and USD 6 billion in revenues due to pollution-induced absenteeism (2019). Employees mostly chose to overwork to recompense the lost time, which lead to burnout, enfeebling, and difficulty to attract talent.Sectors like investment banking, software development, and others that require major brain work get hit seven times more than other sectors due to air pollution-related issues and absenteeism. The IT sector in particular faces a loss of about USD 1.3 billion, 1% of the total sector value. With compensatory presenteeism and overworking, it is found that only 10% of employees can take leaves on days when the AQI is highest.

- **Faltering consumer base when air quality degrades-** People tend to stay indoors when the air quality affects the execution of most activities including the essential ones. Consumer-facing businesses could have gained revenue of USD 2.2 billion if pollution was under control. The retail sector and restaurant business face the biggest hit.
- **Premature deaths taking a toll-** 3.8 million working days are lost as India combats pollution-related death which translates to about 18% of total working days. The working life of the labourers is cut short due to the horrors of air pollution, impacting the families of the victims and limiting their economic contributions.
- **Reduced lifespan of business assets-** Pollutants like Sulphur dioxide and Nitrogen oxide degrade the electronic and metal machines and devices used in the IT sectors, reducing their shelf life to 3/4th of the estimated span. The frequency of replacement increases and leads to company costs being escalated. Stunted flower and crop growth in agriculture due to air-borne pollutants cause a loss of 5-12% loss in yield every year (Dalberg Advisors).

- **Hit on Tourism**- Monuments and museums of Indian heritage and history are major attractions to tourists. Air pollution causes degradation here as well. Monument buildings exposed to outdoor pollution eradicate quickly and the indoor polluted air tends to cause rusting of the relics placed inside. With time the degradation increases, also increasing the cost of repair and maintenance. The actual cost may vary, annually the Indian government spends about INR 8 lakhs per monument, per year (Natarajan et al., 2022).

Social and Cultural factors:

Man's life was made easier after the Industrial Revolution but along with it came air pollution problems (STEAR, 2021). The social and cultural factors highly contribute to the deteriorating quality of air in Indian cities.

Major Hindu festivals like Holi, Diwali, Ganesh puja, and Durga puja are vibrantly celebrated. Traditional activities like cremation have led to the rise of pollutants over the years, affecting both health and biodiversity. Incense smoke from religious ritual places emits a large number of carcinogens (causal agents of cancer) and health-damaging compounds, including particulate matter, nitrogen and sulfur oxides, Volatile Organic Compounds (VOCs) such as benzene, 1,3 butadiene, styrene, formaldehyde, etc. Temple workers were found to be exposed to a higher concentration of benzene and 1,3-butadiene than other control workers in a 2013 study.

Synthetic organic and natural biomaterials are burnt in various proportions during Indian religious and ritual practices like marriage ceremonies. The sprinkling of liquid ingredients like oil and holy waters, over combustible materials in religious activities results in frequent variations of pollutants emitted into the surrounding air.

High amounts of VOCs are released into the air during burning practices like agricultural crop residue burning, rice straw burning, fossil fuel combustion, transportation, industrial sectors, forest fires, etc. CO_2 levels were highest around marriage ceremonies because of biomass burning and lowest near Muslim graveyards (Dewangan et al., 2013).

In Bhubaneswar, the PM_{10} aerosol levels in the ambient air were monitored during Diwali week. Particulates, gases, and dust in the air increase during the festivities and fireworks. The results indicated that PM_{10} values escalate during and post-Diwali week compared to the pre-Diwali week. Although the difference is not high as Bhubaneswar has a lot of steel plants that contribute to the reduced air quality all year round (Sasmita, Kumar, 2022).

A study conducted in the Indo-Gangetic plain (IGP) (Chakrabarty, 2021) showed a dominance of SC and ST tribes living in conditions where the air quality was poor, showing high concentrations of $PM_{2.5}$ in the areas due to the conventional use of biomass, and fossil fuels, and gasoline for cooking. Many industries are set up in these areas, including coal mines and fuel-run power plants that contribute to the rise in hazardous air pollutants.

Children of seven years and above are generally expected to have basic reading and writing skills. This population is often taken to analyze the socio-economic prospects of a particular region. Literacy can shape a population's capacity to accept the existence of pollution as a result of its own economic development or to challenge it through access to effective political power.

In districts where $PM_{2.5}$ levels exceed international standards, at least 85% of the population and households are found to belong to socially disadvantaged categories. 55.6% of the population in these districts are illiterates, SCs, STs, and children. This points towards the direct relation of social capability, income, illiteracy rates, and living standards readily contributing to the increase in air pollution (Chakrabarty, 2021).

It is astonishing that depression, a mental illness is associated with air pollution. Research has shown that inhalation of $PM_{2.5}$ from the heavily polluted air of low and middle-income areas may increase the risk of depression, which directly leads to the increase in tobacco smoking of the victims yet again contributes to the worsening of the air quality in places where the AQI is already pointing towards "Hazardous" (Lin er al., 2017).

SOURCES OF AIR POLLUTION

In Odisha, the major causes of air pollution include fuel burning, household combustion, vehicles, and industries. Depending on the commercialization of cities, increasing population, and increasing industrialization, the AQI value fluctuates daily.

Several reforms are adopted by the State Pollution Control Board, Orissa to combat the increase in air pollution. Recognizing the sources of air pollution was challenging until recent years due to the usage of manual Air Quality management in various cities of Odisha. Installation of real-time Air Quality Meters by the Air Quality Monitoring Committee, Government Of Odisha (2018) has widely helped assess air quality over areas (Odisha Air Quality Monitoring Committee).

Generally, over the years, it has been seen that the sources can be subjective to cities and towns like Angul and Talcher Industries, coal mines, thermal power plants, and road dust contribute to the pollution. In Balasore, vehicles are the major cause. In Bhubaneswar, construction tops the list along with vehicular emissions and road dust.

Compiling data from various pieces of literature and research projects, the major sources of pollution in Odisha that harm the urban air quality are as follows (OSPCB):

- **Vehicles-** Vehicular emissions are a major source of air pollution in cities with an urban prospect of living like Bhubaneswar. They include pollutants like carbon monoxide, hydrocarbons, nitrogen oxides, particles, volatile organic compounds, and sulfur dioxide. Since the emission is at the ground level, vehicular pollution causes more harm to the population than industrial emissions.

  The annual purchase of vehicles is increasing, especially after the COVID-19 outbreak, where people tend to feel safe in their own private cars and bikes than in public transport in a desperate attempt to avoid infections. With the rapid elevation in automobile purchases, air quality will drop to tremendous levels (OSPCB). Rapid increases in the registration of motor vehicles are seen in Bhubaneswar, Cuttack, Balasore, Angul, Talcher, and Rourkela. Bhubaneswar, out of all the non-attainment cities has seen the maximum rise in vehicle stock with two-wheelers dominating the fleet. Bhubaneswar also has the highest number of private cars.

  The usage of petrol and diesel in automobiles results in the release of unburned hydrocarbons (HC), carbon monoxide (CO), nitrogen oxides (NO_x) or particulate matter (PM), and surface ozone.

- **<u>Diesel Generators (DG) Sets</u>-** A DG set is a combination of an electrical generator with a diesel engine to generate electricity. Cities like Bhubaneswar experience one-hour power breaks daily, making the usage of DG sets necessary. Based on a detailed survey, due to power breakdowns of 1 hour daily; a number of DG Sets are used in Bhubaneswar City. 8,946 DG Sets operate in the city. The total diesel consumption daily was 16.11 kl/day

- **Brick kilns**- A Brick kiln is an area where bricks are burnt or broken. In Odisha, brick kiln units (about 25 lakh bricks) are 500 and the ones producing 5 lakh bricks are 5000. These are largely located on the outskirts of cities but definitely pose a transboundary effect on the urban air quality of the non-attainment cities.

  Conventional kilns are highly polluting. Balasore and Rourkela have the highest number of kilns, some are present in Bhubaneswar, Angul, and Cuttack. During the 10-15 minutes charging phase, the emission from brick kilns is highest, effusing a thick black smoke, and for the remaining period, greyish smoke is observed over the kilns.

  Particles or pollutants that have an elevated concentration in the smoke are above 5 microns, and the dust particles' dispersion covers a radius of 200m to 1000m. A distance of 500m is marked as a 'high' risk area and a distance of 1km has been taken as 'medium'.

- **Stone Crushers**- With about 19 stone crushers operating in the city, the quantity of dust in the air increases daily. They are mostly situated near highways and use stones from roadsides and major cities for crushing, grinding, and refining stones.

Topographical factors and wind aid in the dispersion of these pollutants. It was seen that the suspended particles measured between 3-10 microns. Jaw crushers are used in most stone-crushing units that do not have any pollution control devices. The crushed particles are kept in the open which facilitates the dissipation of suspended particles.

The EPA (Environmental Protection Agency, USA) emission factors for dust generation are used to calculate the estimate of the pollution load from such units. An alarming estimation of about 1869 tonnes per day of SPM (Suspended Particulate Matter) is released from these stone-crushing units.

- **Industrialization-** Rapid industrialization forms a well-defined industrial belt and clusters that contribute to the increasing air pollution. Handling at a local level has become compulsory to regulate air quality in these states. In Odisha, districts like Angul, Talcher, Rourkela, Balasore, and even areas around **Cuttack** have a large number of industries operating that fall in the 'red' and 'orange' category and directly influence the densely populated urban air quality.

  Bhubaneswar alone has **88 flourished industries** out of which 16 are affecting the air quality (State Pollution Control Board, Odisha).

  A comprehensive analysis of air quality in the Jharsuguda district of Odisha which is already identified by the Government of India as a highly polluted industrial area (Mishra and Mohanty, 2009) shows that the geologically rich coal reserves and abundant availability of surface water from the Hirakud Reservoir make the region a major attraction for various industries.

  The major contribution of air pollutants is the usage of fuels (firewood, coal, Liquefied Petroleum Gas, High-Speed Diesel, Kerosene, and furnace Oil), SPM, and NO_x in these industries. The air pollution load from the industrial sector in Odisha is about 3.73 tonnes/day for SPM and NO_x of 0.18 tonnes/day because of coal and coke by the industries. Keeping in account the meteorological conditions, these industries can potentially harm the air quality within a radius of 2 km to 5 km.

- **Power generation-** Thermal power plants run on fuel and release harmful by-products like Carbon dioxide (greenhouse gases), Sulphur dioxide, Nitrogen oxides, and primarily ash (PM and heavy metals) (AZO Cleantech, 2019).

  In Odisha, there are seven running power plants, 24 in Jharsuguda, Angul, and Dhenkanal. 14 power units are found in Angul. A centrally located town, Dhenekal has three operating power plant units. This data clearly indicates the towering impact power plants and power stations have on air quality (Chakraborty et al., 2021)

- **Construction and demolition-** Construction and demolition waste get dumped in zones that are fragile ecologically and produce a major quantity of dust that is partly responsible for the degradation of the environment. Most of these wastes are inert and have reusability potential, but that seldom happens. From a calculated analysis according to the guidelines on environmental management of construction and demolition wastes, it was seen that Bhubaneswar generates approximately 196.8 tonnes per day (Lin et al., 2017)

- **Household and domestic emissions-** Odisha is the 11th largest state by population. Odisha's population is projected to be 4.41 crores (Aadhar India, March 2022) With the majority of the population being slum dwellers, who use conventional methods (kerosene, coal, and wood) for cooking. The rest of the population is dependent on LPG (Liquid Petroleum Gas).

  With a massive consumption of 13.69 tonnes/day of coal, 13.69 tonnes/day of wood, 06.84 tonnes/day of cow dung, 57.0 tonnes/day of LPG, 47.14 kl/day of Kerosene, the air pollutants released are shooting for the sky. The substantial pollutants released due to household combustions and domestic use of fuels are SPM, NOX, CO, and Hydrocarbons. Perhaps, the use of solid fuels poses a threat to indoor and outdoor air quality, rendering harmful health effects for the growing population daily (Chakraborty et al., 2021).

- **Road dust-** Dust from roadsides and industries accumulates and carries toxic substances that come from multiple sources, proving to be a health hazard. The Angul-Talcher belt is heavily populated due to roads running through coal mining areas. Expansion of infrastructure (transport, institutional and basic services), and digging of roads have become common practices promoting the formation of road dust and wind dust. Poorly paved roads with a lack of vegetation are another reason for the hike (Lin et al., 2017)

  A study conducted on the plants found near industrial areas showed significant effects of air pollution. Since there are no chemical or mechanical means or devices formulated yet to eradicate air pollution, nature is the only reliable source. Plants take up heavy metals from the air and use them for metabolic purposes.

  However, the increasing amount of atmospheric pollutants indirectly affects the health of these natural soldiers too. Samples of roadside plants were used to devise the data and XRF (X-ray fluorescence) analysis was done that indicated a decrease in leaf area in all plant species growing on roadsides with heavy traffic and industries.

  Vegetation provides a large surface area that acts as a significant sink for air pollutants. Plants can absorb atmospheric gases without active metabolism, or they can actively metabolize them, creating concentration gradients that facilitate continued absorption, in most cases, this adversely affects plants.

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  It was seen that Iron oxide (Fe_2O_3) was present in the highest concentration, followed by manganese oxide (MnO), titanium dioxide (TiO_2), zinc oxide (ZnO), copper oxide (CuO), and chromium oxide (Cr_2O_3). Traces of As, Ga, Re, Yb, Eu, Th, Nb, Zr, Y, Rb, V, Ti, Si, etc were also found. This indicates how hazardous is the air we breathe daily (Das et al., 2022).

- **Agricultural activities and forest fires-** Regional-level pollution also affects the urban air quality to a great extent. Burning of Agricultural stubble, large-scale open fires, and crop residue burning have a serious impact. Seasonal and episodic forest fires are another supplier of air pollutants. In Odisha, during March-April-May, during the rabi harvest season and dry summer, forest fires are evident and plausible (Satellite images from NASA). The fires become infernos in no time and can impact the urban air quality of the non-attainment states readily (Lin et al., 2017).

SEASONALITY AND AIR QUALITY:

The Indian sub-continent experiences three major seasons, Summer-Monsoon-Winter. These seasons provide to boost the Indian economy, but they are also regulators of pollution. It has been seen that the air quality tends to degrade in summers and winters, because of vehicular movements, mining, and industrial activities. During monsoons, the air quality becomes 'good' and 'satisfactory' due to heavy precipitation and various meteorological activities, depressions, and cyclones arising in the Bay of Bengal (Panigrahi et al., 2013).

The North Indian winter smog during early November, starts to engulf the eastern side during late December and early January. The high local pollution is trapped due to winter inversion and eastern states like Bihar, West Bengal, and Odisha is mostly affected (OB Bureau, 2022).

A recent report (2022) suggests that the peak in $PM_{2.5}$ levels was highest during summer in East India, making it the maximum in all regions. It also suggested that this year, the smaller and upcoming cities were pollution hubs rather than mega cities (CSE, 2022).

Increased modes of transportation, rapid industrialization, urbanization, and crowding of cities have led to the rise in levels of SPM, RPM, SO_2, NO_x, and CO in megacities. These pollutants show an elevation in winter than in summer or rainy seasons. Primary air pollutants emitted into the air facilitate the formation of secondary air pollutants as a product of the reactions between two or more pollutants that go on in the atmosphere. The number of pollutants emitted, and the ability of the atmosphere to disperse or absorb the pollutants, along with physical and chemical factors and self-purification processes, determine their concentration in the air.

Vehicle exhausts contain major toxins and pollutants like **NO_x, CO, HC,** and **PM**. The SPM concentration peaks during winters whereas in summers and monsoons, they tend to remain within prescribed limits. Transportation, industries, and conventional combustion of fuels, roadside dust, and traffic turbulence, source the emission of RPM (Respirable Particulate Matter). It is observed that the RPM concentration steadily increases in all three seasons (Ekka et al., 2022).

Polycyclic aromatic hydrocarbons (PAHs- a class of chemicals found naturally in coal, crude oil, and gasoline) determined by the U.S. Environmental Protection Agency were detected in Orissa during bimonthly (twice a month) sampling of PM_{10} and $PM_{2.5}$, input from industrial areas of the state.

In Orissa, the pre-monsoon, monsoon, and post-monsoon seasons were studied (Ekka et al., 2022) to detect the concentration of these harmful chemicals in the air and the highest average concentration of PAHs in $PM_{2.5}$ was observed in the post-monsoon season (170 µg/m^3), followed by the pre-monsoon season (48 µg/m^3) and monsoon (16 µg/m^3) period. A similar trend for PAHs was also observed at PM_{10}, with high concentrations observed during the post-monsoon season (286 µg/m^3), followed by pre-monsoon season (81 µg/m^3) and monsoon season (27 µg/m^3).

The main sources of atmospheric PAH pollution in Orissa are **burning diesel, gasoline, and coal.** Analysis revealed that PAH concentrations were primarily influenced by air masses originating from the northwest and passing through central India (Ekka et al., 2022) (OB Bureau, 2022)

Although seasonal variations in pollution are also regulated by many surface-level factors such as vehicular transportation, operation of mines, thermal power plants, etc., it is devised that winter is the most '**air pollution friendly'** season of all.

AQI CALENDAR

INSIGHTS FROM THE AQI CALENDAR

The average air quality of Sambalpur, Rourkela, Bhubaneshwar, Cuttack, and Konark is classified as poor. This is due to the presence of industrial clusters in the districts of Rourkela and Sambalpur. Rourkela is also popularly known as Ispat Nagar or the steel city of India. It has one of the largest integrated steel plants that is set up with German collaboration, known as the Rourkela Steel Plant or the Steel Authority of India Limited (SAIL). India's first public sector steel plant facility was set up in this city. Industrial emission is the major source of pollution in this region, followed by vehicular emissions.

According to the data published by the Odisha State Pollution Control Board (ospcboard.org), the average AQI value for November 2022 in Bhubaneshwar is 142, indicating that the air is moderately polluted. According to the Sameer app, Talcher city, which is 130 km from Bhubaneswar has a moderate AQI, with a maximum value of 184 on the 6th of November.

The action plan prepared by CPCB includes components like identification of sources and its apportionment considering sectors like vehicular pollution, industrial pollution, dust pollution, construction activities, garbage burning, agricultural pollution, and residential and indoor pollution. Bhubaneshwar and other cities of Odisha are experiencing a progressive degradation of air quality due to the above-stated sources, coupled with poor environmental performance, and ineffective environmental regulations.

TEMPORALITY AND AIR QUALITY

Monitoring the ambient air quality has evolved over the years with the increase in air pollution. Initially, it was done manually by setting up AAQMS (Ambient Air Quality Monitoring System) or Manual Air Quality Monitoring Systems. Under this system, ambient air is sampled by the device, and after a few days of data collection, a manual transfer of data is sent to the analysis stations. A report is manually generated on the basis of the data analyzed and finally, the data is archived in the server. The entire process takes 2-7 days to complete.

With the advancement in science and technology, CAAQM was developed. It uses high-end AI technology to automate the data collection, transfer, and analysis in the central server. All of it happens in real-time and the data is analyzed automatically with advanced AI and archived or used accordingly (OIZOM).

Air quality monitoring requires the following:

- Selection of pollutants
- Selection of location
- Frequency and duration of sampling
- Techniques of sampling
- Proper infrastructure
- Human power
- Operation
- Maintenance.

High traffic density, human population, and distribution, industrial growth, public complaints, emission sources, land use pattern, etc, are the factors considered when selecting a location to study or monitor. Domestic and industrial burning of coal and sulphur-containing fossil fuels typically causes high levels of smoke and sulfur dioxide in the air.

A major threat to clean urban air is vehicular emissions. Carbon monoxide (CO), oxides of nitrogen (NO_x), volatile organic compounds (VOCs), and particulate matter (PM_{10} and $PM_{2.5}$) are toxic pollutants released due to the burning of petrol and diesel.

Fine particles contain microscopic solid or liquid components that can easily penetrate our pulmonary system and cause serious health problems. Sunlight acts on NO_2 and VOCs released from vehicle leads and causes a photochemical reaction that facilitates the formation of ozone which is a long-range secondary pollutant affecting areas far from the emission source.

The size of the particulate matter defines the behavior of the contaminants. Particles with a 50-micron diameter are visible collectively and tend to settle down quickly, perhaps these are not long-term pollution hazards. Particles having less than 50 microns in size are significant air pollutants. They can remain in the atmosphere for extended periods of time and can further react to form secondary pollutants.

The OSPCB (Orissa State Pollution Control Board) monitors the ambient air quality of 32 selected locations all over the state, in districts namely Angul & Talcher, Balasore Berhampur, Bhubaneswar, Cuttack, Kalinganagar, Konark, Paradeep, Puri, Rayagada, Rourkela, and Sambalpur.

Four major pollutants, Sulphur Dioxide (SO_2), Oxides of Nitrogen(NO_x), Suspended Particulate Matter (SPM), and Respirable Suspended Particulate Matter RSPM (PM_{10}) are monitored over the years using pan CPCB guidelines, "8-hour sampling for SPM and RSPM (PM_{10}), 4-hour sampling for SO_2 and NO in 24_x hours of a day with a frequency of twice a week for 104 observations in a year ".

In the last 16 years, the trends of air pollution have been meandering and extremely subjective to the type of air pollutant being monitored.In Bhubaneswar for example $SO_2$and NO_2 levels were seen to be below average mostly. SPM and RPM levels were shooting but were affected due to seasonality and the Covid-19 lockdown. On the other hand, the levels of $PM_{2.5}$ were remarkably within prescribed limits.

In Cuttack city, SO_2 and NO_x were below their respective limits, RPM was high and the $PM_{2.5}$ levels exceeded the prescribed limits. In the Angul-Talcher belt, SO_2 and NO_x were low, SPM and RPM were exceeding the limit and $PM_{10}$was extremely high.

The standard for PM_{10} in the atmosphere approved by the central government is 60μg/m^3. The Ministry of Environment, Forest and Climate Change, Government of India has set up a portal called PRANA (Portal for Regulation of Air-pollution in Non-Attainment cities) for monitoring and implementing NCAP (National Clean Air Programme) which will aid in tracking the physical and financial status of implementation of the City's Air Action Plan and disseminate information to the public about NCAP's air quality management efforts.

On the basis of the data provided by the CPCB, Govt. of India, the monitored PM_{10} values for the non-attainment cities of Odisha are as follows:

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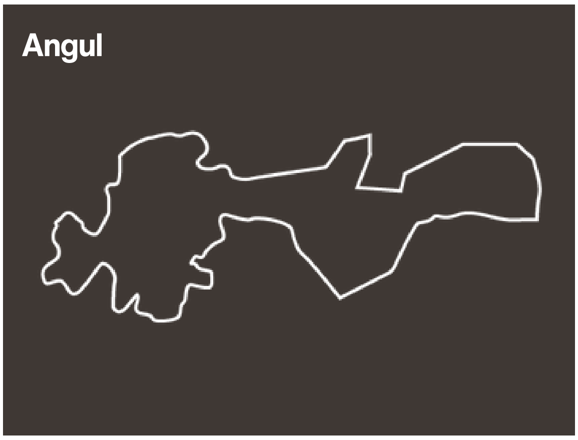
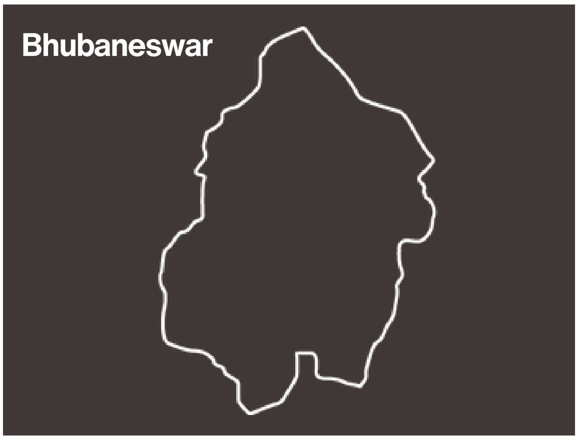


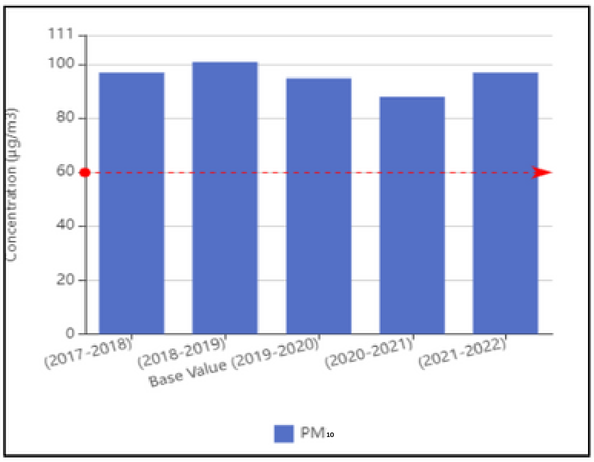
- Assessing the data from 2017-2022, the PM_{10} value has seen a rise from 97 $\mu g/m^3$ in 2017-18, highest in 2018-19 with the value being 101$\mu g/m^3$ and then again back to 97$\mu g/m^3$ in 2022.

- 2017-18, the PM_{10} value was about 84 $\mu g/m^3$ and fell to 78 $\mu g/m^3$ during 2020-21 due to COVID-19 and has since been steady as the 2021-22 data shows a further fall in the concentration resulting in 74 $\mu g/m^3$.

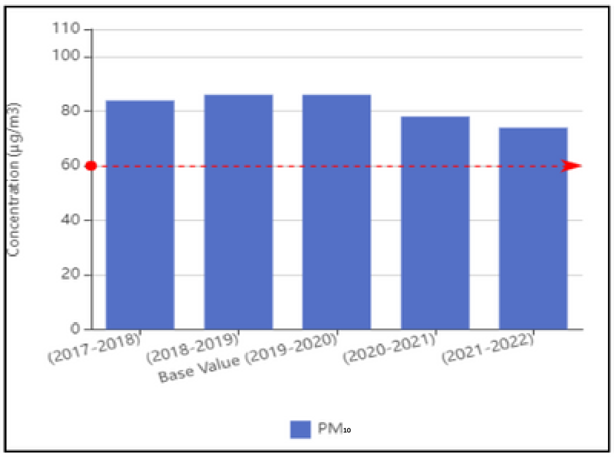


- Bhubaneswar witnessed values closer to the standard set by the CPCB in 2020-21 due to the influence of the unprecedented lockdown. The value recorded during this time is down to 78 $\mu g/m^3$. The pre-covid period (2019-20) had the highest concentration of PM_{10} in the ambient air, up to 103 $\mu g/m^3$.

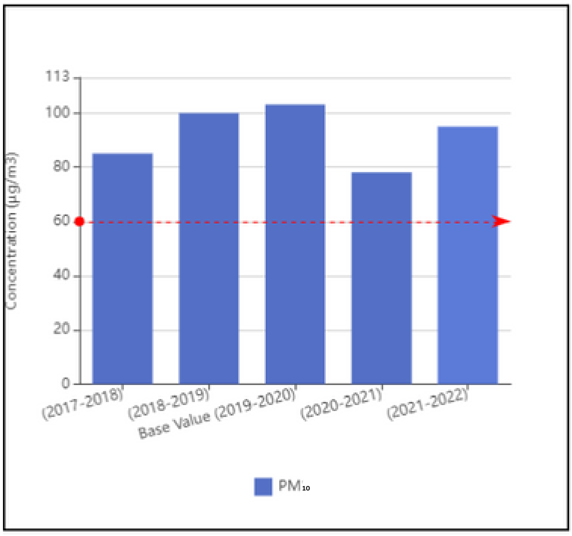
PM_{10} level in Angul



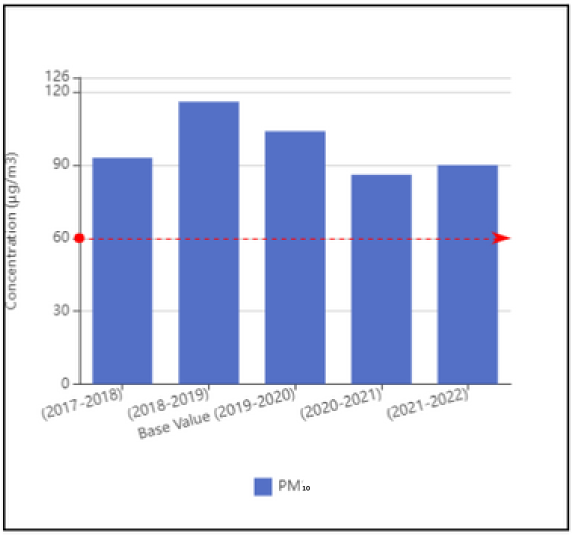
PM_{10} level in Balasore



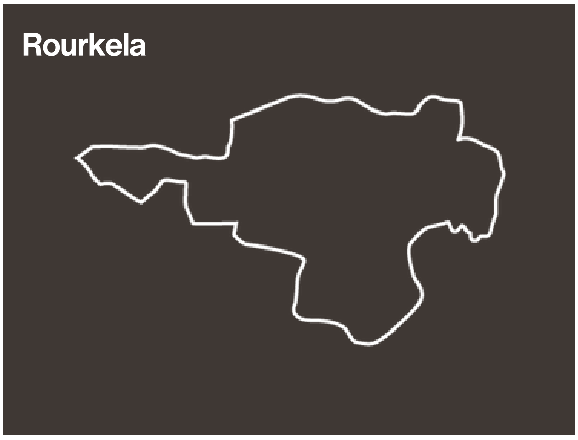
PM_{10} level in Bhubaneswar



PM_{10} level in Cuttack



- Highest PM_{10}, 116µg/m^3, in the ambient air was recorded in 2018-19 in Cuttack, the pre-covid time, and then saw a drastic fall during 2020-21, as low as 86µg/m^3 . In 2022 there is a trial to maintain values as low as possible with the current data suggesting an average concentration of 90µg/m^3 throughout the year.



- Due to the location of industries in and around Rourkela, the PM_{10} value in the ambient air did not witness much fall. In 2017-18, the value was recorded to be 99$\mu g/m^3$, rising to 118$\mu g/m^3$ in 2018-19 and again to 106$\mu g/m^3$ in 2021-22 from 96$\mu g/m^3$ in 2020-2021.

- Talcher falls in the industrial belt of Odisha. There are operating industries that were not shut down during the pandemic as it would hinder essential goods production. 122$\mu g/m^3$ of PM_{10} in the ambient air was recorded in 2019-20. Also during the pandemic lockdown, the values didn't go below 98$\mu g/m^3$.

COVID-19 AND ITS EFFECT ON AIR POLLUTION

The AQI dropped rapidly during the global lockdown due to COVID-19, an infectious disease caused by the deadly virus SARS-CoV-2 that became the reason for around 60,685,626 deaths in Southeast Asia alone (WHO). In order to reduce the transmission of infection, the Indian Government confined the entire population in an unprecedented lockdown, shut large portions of major industries, and brought vehicular transport to a standstill, which led to a decrease in anthropogenic emissions and subsequently improved the urban air quality. The first case of COVID-19 was detected on the 16th of March 2020 in Odisha, leading to the implementation of a nationwide lockdown from the 25th of March 2020, thus limiting the movement of 1.3 billion people in India.

However, essential services like water, electricity, municipalities, hospitals, banks, food stores, and movement of essential goods trains and trucks were exempted from the lockdown. Despite the lockdown, steel industries, thermal power plants, production and distribution of fuels like coal, and mining activities, in and around Odisha were kept operational as 'essential services, although there was a reduction of production by 60% due to a fall in the number of workers (Economic times, 2021).
The level of pollution is subjective to rural and urban cities. In general, studies on India reported

decreases in aerosols, NO_x , SO_x , CO, CO_2 , and increases in surface ozone (O_3) during lockdown periods (percentages vary by pollutant and city), the benefits of a cleaner environment due to the lockdown had been advocated (Paital, 2020).

Keeping in account the pandemic and the drastic changes in lifestyles during and after the lockdown, did affect the air pollution levels globally. The seven non-attainment states of Odisha were no exception. Various pollutants significantly rose while others remained the same without fluctuating and some reduced to non-hazardous levels. For example in Bhubaneswar, it was expected that air pollution has reduced significantly due to the reduced usage of vehicles and non-functional industries, but data collected from conducting various studies in different locations of the city paints a different picture.

On a particular level, the data fluctuates and is subjective to the type of pollutant being talked about. The study shows that $PM_{2.5}$ and PM_{10} increased significantly (rather than decreased), O_3 increased, and CO and NO_x decreased during the lockdown period (Sahu et al., 2020). The study was conducted using US EPA-approved analyzers and weather parameters (humidity, solar radiation, temperature, wind speed, and direction). The values indicated a significant increase of $PM_{2.5}$ (up to 40.26%) and PM_{10} (up to 1.92%) over Bhubaneshwar in 2020, compared to 2019.

There is a high chance that the operational coal mines during the lockdown period were the major contributors to the increase of PM values in Bhubaneshwar air. Another factor is the burning of coal and wood in residential areas since it is a cheap and free energy source. There was hardly any decrease in the O_3 values either. One thing to be taken into account is that CO and NO_x are involved in O_3 generation/destruction, which shows an alarming decrease during the lockdown period, perhaps this might have affected the accelerating values of surface O_3 over the capital city of Odisha.

As it is known, meteorological conditions play a significant role in reducing or escalating air pollutants. It was seen that rainfall in the pre-lockdown and the lockdown period, due to depression in the Bay of Bengal affected the air quality in this region. The Odisha coast was hit by cyclone “Amphan” on the 20th of May 2020 which changed the picture completely. The coast was washed off of air pollutants, thereby improving the the quality of air in Odisha.

A significant reduction of primary and secondary pollutants during the lockdown period, as compared to that of the pre-lockdown period is attributed to the reduced anthropogenic and vehicular activities across the state. There was more than a 50% reduction in black carbon and a 40% reduction in surface ozone as a result of a combined effect of rainfalls, winds, cyclones, and the lockdown. On the other hand, CO was hardly impacted by these changing conditions.

Post lockdown or after the ‘unlock’, many cities in India are undergoing repair since the pandemic and the lockdown crashed the global economy enormously. Odisha is going through significant development in the construction of roads, residential areas, and shopping malls and advancement in the usage of anthropogenic methods, to get the cities in the state up and running.

In order to avoid the infection of road, the purchase of vehicles has gone up, people tend to avoid public transport and around 70% of the population now own personal vehicles, definitely contributing to the slow decline of the air quality which was repaired to a great extent during the lockdown. Although there was still a decline in air pollutants recorded during the unlock period, owing to the meteorology of the onset of the monsoon (Panda et al., 2021).

HEALTH HAZARDS OF AIR POLLUTION

Air pollution is one of the world's leading causes of death, with the various effects of air pollution killing approximately 4.2 million people worldwide each year (WHO)

Exposure to fine air pollutants ($PM_{2.5}$ and PM_{10}) leads to diseases related to the **heart, lung cancer, strokes, COPD** (Chronic Obstructive Pulmonary Disease), and respiratory infection like **pneumonia** (WHO).
Long-term and short-term exposure to atmospheric toxins imposes health risks, more severely to people who are already ill, marginalized groups, elderlies, and children. According to the OSPCB, Bhubaneswar alone records a high number of air pollution-related ailments, primarily lung cancer, **premature deaths of the fetus, and cardiovascular diseases** (Odishabytes, 2019).

PM penetrates the respiratory tract via inhalation and becomes a leading cause of pulmonary infections, cardiovascular diseases, reproductive and central nervous system (CNS) dysfunction, and Cancer. The ozone layer is naturally designated to protect human life from harmful Ultraviolet (UV) radiations but the substantial depletion of the layer in the stratosphere is making it easier for UV rays to penetrate and pose harmful effects at ground level as surface O3 is increasing.

Volatile Organic Compounds (VOCs), dioxins, and polycyclic aromatic hydrocarbons (PAHs) are all considered air pollutants that are harmful to humans. CO causes direct poisoning if breathed at hazardous levels and can lead to chronic intoxication. All the harmful pollutants suspended in the air are a source of pulmonary ailments like **COPD, asthma, bronchitis, lung cancer, and cutaneous diseases** too (Manisalidis et al., 2020).

One in 10 persons in the world lives in cities that comply with the WHO air quality standards. According to the Global Burden of Disease study, more than 1,00,000 (Deccan Herald) premature deaths per year, attributing to ambient air pollution (Khilnani, Tiwari, 2021). In 2022, about 23 lakh deaths were recorded.

Out of the total death toll in India, 1.67 million, i.e., 17.8% of deaths were attributed to air pollution in 2019. 0.38 million deaths were caused due to ambient PM air pollution and 0.61 million were due to household or indoor air pollution. Ambient ozone air pollution solely caused 0.17 million deaths.

Of the total deaths related to air pollution, **39.5% were due to lung diseases (COPD and lung cancer), 24.9% were due to Ischaemic heart disease, 13.7% were due to strokes, 5.5% were due to diabetes and 1.5% were due to cataract.**

Increased mortality due to particulate air pollution reflects increased pollutant emissions due to increased energy consumption, accelerated urbanization, rapid industrialization, and an increase in fossil-fueled vehicles. There is evidence that climate change may amplify the negative effects of air pollution through atmospheric stagnation, temperature-related increases in $PM_{2.5}$ concentrations, and ground-level ozone formation, which are particularly acute in India (Global Burden of Disease Study 2019).

In Odisha, the major hazard to health is imposed heart diseases, Lung diseases, and premature deaths due to the same. An insight into the relation of pollutants with some major diseases is as follows:

- **Cardio-vascular diseases**- Long-term exposure to particulate matter and nitrogen oxides at levels approaching the National Ambient Air Quality Standard (NAAQS) could prematurely age blood vessels and contribute to the rapid accumulation of calcium in the coronary arteries. This accumulation of calcium restricts blood flow to the heart and other major blood vessels, increasing the likelihood of cardiovascular events such as heart attack and stroke.

  Using air quality and collected medical data, researchers found a direct relationship between air pollution and plaque buildup. Long-term exposure to air pollution has accelerated atherosclerosis cases in healthy people with an increased risk of a heart attack. In fact, researchers found that the higher the exposure level, the faster the progression of atherosclerosis (USEPA).

  There is a significant 0.5% to 1.5% increase in cardiovascular disease for every 5-6 $\mu g/m^3$ increase in $PM_{2.5}$ Furthermore, there is a 69% increase in cardiovascular death after acute exposure to particulate air pollution.

  Mortality due to cardiovascular disease is 69% vs. respiratory disease 28% currently. It is also calculated that a 0.68% increase in cardio-pulmonary mortality was associated with a 10 $\mu g/m^3$ increase in $PM_{2.5}$ on the day before death with a corresponding increase in hospitalization relating to ischaemic heart disease and congestive heart failure.

  It is well known that both air pollution and elevated blood pressure contribute to an increased risk of cardiovascular disease.

It is seen that particle exposure was associated with a significant increase in blood pressure. These studies showed that for every 10.5 µg/m^3 increase in $PM_{2.5}$ levels, systolic blood pressure (SBP) increased by 2.8 mmHg and diastolic blood pressure (DBP) increased by 2.7 mmHg (Lee et al., 2014).

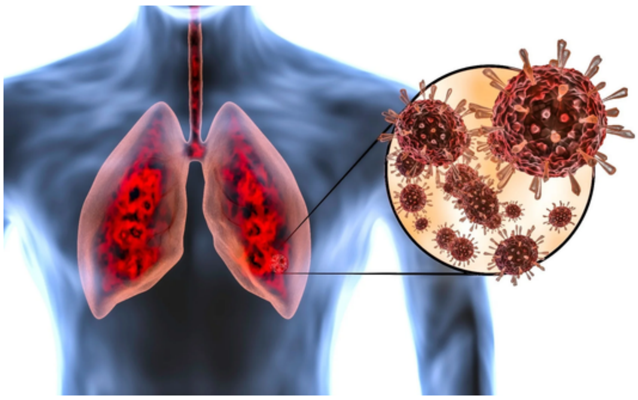
- **Pulmonary and respiratory disorders**- SPM and RPM concentrations in and around industrial sites are higher than in residential areas. Air pollution also affects local residents with respiratory diseases such as black lung, bronchitis, asthma, and pulmonary fibrosis, as well as many other diseases such as eye irritation, hypertension, and lung cancer.

Many suspected tuberculosis patients were studied in the Jharsuguda district of Odisha showing it to be the highest-caused disease due to SPM and RPM from industries in this district (Swain et al., 2021). Particles less than 10 µm in diameter (PM_{10}) enter the lungs after inhalation and can even enter the bloodstream. Particulate matter, PM_{10} , poses a major health risk irrespective of short-term and long-term exposure to $PM_{2.5}$ and was shown to be positively associated with acute nasopharyngitis (WHO).

Paradeep, Jagatsinpur is known as one of the most polluted areas in Odisha, according to the **Comprehensive Environmental Pollution Index (CEPI).** Air pollutant emissions are responsible for an estimated 94 deaths annually. Air pollution also leads to emergency room visits due to **asthma and lower respiratory infections and lung cancer** (CREA, 2021)

Carbon monoxide is produced by fossil fuels during incomplete combustion. Symptoms of carbon monoxide inhalation poisoning include **headache, dizziness, weakness, nausea, vomiting, and eventually unconsciousness.**

The affinity of carbon monoxide for hemoglobin is much greater than that of oxygen. Therefore, prolonged exposure to high concentrations of carbon monoxide can lead to severe poisoning. Hypoxia, ischemia, and cardiovascular disease are observed due to the loss of oxygen through the competitive binding of carbon monoxide (WHO).



- **Reproductive health**- Odisha is still home to conventional methods of cooking like using coal, dung, or biogas for cooking purposes. Women are more often exposed to indoor air pollution where suspended particulate matter can be associated with the detrimental reproductive health and pregnancies of these women. Even in urban spaces, usage of LPG is not the only mean of household cooking, many residents accompany it with kerosene stoves too.

Indoor air pollution contributes to the ambient air quality of a region considerably and also increases outdoor air pollution. From a general perspective, pollutants are responsible for low birth weight, fetal deaths, and stillbirths along with the acceleration of post partem depression.

Ambient air pollution due to particulate matter is seen to be associated with low birth weight and Intrauterine growth restriction (IUGR). Exposure to TSP (Total Suspended Particle) in the third trimester was significantly associated with LBW (Low Birth Weight). Every 10 μg/m^3 increase in $PM_{2.5}$ increases IUGR risk by approximately 6-7% after accounting for other risk factors (Xu et al, 2011). Particulate matter (PM) pollution is a risk factor for anemia in women of the reproductive age group (The Telegraph, 2022).

Increased NO_2 and SO_2 exposure in the first, second, and third trimesters of pregnancy is associated with an increased risk of IUGR by 16%, 14%, and 16%, respectively. Studies have reported the impact of various air pollutants such as PM, NO_x, SO_2, and CO on PTD (Preterm Delivery).

Strikingly, air pollution also adversely affects fertility in men. Gametogenesis in both sexes is hindered in delivering a number of gametes and in detrimental quantity and effects at the epigenetic level. Exposure to $PM_{2.5}$, NO_2, and O_3 has been regarded to develop erectile dysfunction and decreased libido in men. Further, long-term exposure to atmospheric toxins increases the risk of damaged sperm production and DNA mutations that might lead to infertility (Kumar et al., 2021).

- **Cancer**- There is now ample evidence from human and experimental animal studies, as well as mechanistic evidence, to support a causal link between outdoor air pollution, particularly outdoor particulate matter (PM), and lung cancer incidence and mortality. Particulate air pollutions is estimated to be responsible for hundreds of thousands of lung cancer deaths worldwide each year.

  Epidemiological evidence for outdoor air pollution and the risk of other cancers, such as bladder and breast cancer, is more limited. Outdoor air pollution may also be associated with reduced cancer survival, although more research is needed (Turner et al., 2020). Cells with cancer-causing mutations naturally accumulate with age but are usually inactive. Air pollution awakens these lung cells, stimulating them to grow and possibly form tumors (Gourd, 2022).

Increased air pollution increases the risk of lung cancer, mesothelioma, mouth and throat cancer. New research suggests that pollution is also linked to an increased risk of death from several other cancers, including breast, liver, and pancreatic cancer (American Association for Cancer research).

Inhalable particulate pollutants, 2.5 microns in diameter in the air - can cause lung cancer even in people who have never smoked (Ghosh, 2022) A meta-analysis of studies of NO_2 exposure, a marker of transport-related air pollution, also reported a significant adverse effect on lung cancer mortality (Gourd, 2022).

GOVERNMENT INITIATIVES TO COMBAT AIR POLLUTION (OSPCB)

The action plan prepared by CPCB includes components like identification of sources and its apportionment considering sectors like vehicular pollution, industrial pollution, dust pollution, construction activities, garbage burning, agricultural pollution, and residential and indoor pollution. Bhubaneshwar and other cities of Odisha are experiencing a progressive degradation of air quality due to the above-stated sources, coupled with poor environmental performance, and ineffective environmental regulations.

- Emission Standards for Tractors: Emission norms for tractors were notified on 8.9.1999 under the Central Motor Vehicle Rules effective from 1.10.1999.
- India 2000 Emission Norms akin to Euro-I Norms: Emission norms known as India 2000 akin to Euro-I norms were notified on 28.8.1997 under the Central Motor Vehicle Rules effective from 1.4.2000 for the entire country, requiring major modifications in the engine designs.

Steps taken to control vehicular pollution followed by the board are as follows:

- Establishment of Ambient Air Quality Monitoring throughout India
- Notification of Ambient Air Quality Standards under the Environment (Protection) Act.
- Notification of vehicular emission norms for years 1990-91,1996, 1998, 2000, 2001
- Improving fuel quality by phasing out lead from gasoline, reducing diesel sulphur, reducing gasoline benzene, etc.
- Introduction of alternate fuelled vehicles like CNG/LPG.
- Improvement of the public transport system.
- Phasing out of grossly polluting commercial vehicles.
- Public awareness & campaigns.

CONCLUSION

35 Indian cities out of the 50 most polluted cities of the world come within this subcontinent's boundaries. Odisha, similar to other cities in India is becoming a significant victim of air pollution. Out of India's most polluted states, Odisha is in the 4th position with seven of its cities falling under the "non-attainment" zone, namely Bhubaneswar, Cuttack, Balasore, Angul, Rourkela, Kalinganagar, and Talcher.

The Atmospheric Air Quality Management Plan proved to be an adequate solution to accelerate the prevention of air pollution-related health risks. The public could access it and understand the non-dimensional AQI of any particular area or region at any given time.

AQI considers the number of pollutants across the globe, preferably $PM_{2.5}$ to measure the overall status of air quality. It is seen that air pollution is affected by a number of factors like seasonality, temporality, pandemics, meteorological factors, and the nature of suspended particles. Odisha sees varying ranges of air quality over the years but a mean of all the data and research shows a substantial increase in the state that houses the first smart city of India.

Due to increased industrialization and urbanization, ambient air pollution is increasing at a steady rate, imposing health hazards on the population. The Covid-19 lockdown also affected the air pollution in Odisha largely, even the period after the lockdown or unlocked period saw an exponential rise in air toxins and cities were trying to combat the tremendous economic loss faced during the pandemic.

Air pollution affects all social and cultural groups, and has been a significant cause of the drop in Indian GDP annually. The government is taking up various initiatives to combat the detrimental impact of air pollution as the challenges are increasing every day. The government needs to adopt more policies that need to be cross-sectional, cross-boundaries, and cross-governmental to adopt an airshed approach towards air pollution abatement. Even the common public needs to take up first-hand responsibility in helping the government reduce the risks of air pollution.

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ANNEXURE:

The NCAP reports of Cuttack and Bhubaneshwar districts of West Bengal are attached in this section-
This policy tracker aims to record air pollution trends and utilize the data in India to paint a picture of the hazards related to air pollution.

What is NCAP?

The central government formulated and launched **National Clean Air Programme** on **10 January 2019** to reduce particulate matter concentration in cities that do not match the **National Ambient Air Quality Standards (NAAQS)** set by the World Health Organization (WHO). This tracker aims to control air pollution nationwide through a collaborative approach involving ministers, state governments, local bodies, and stakeholders for the agenda (NCAP, CPCB).

Clean Air Action Plan for Bhubaneswar

Why is Bhubaneswar under NCAP?

- Currently, there are no real-time air quality monitors functioning in Bhubaneswar. There are six manual stations in Bhubaneswar (OSPCB, 2021).
- Manual stations provide data for two days a week reporting on PM_{10}, SO_2, and NO_2 (Clean Air Action Plan, Bhubaneswar, 2018).
- Bhubaneswar has the highest vehicle stock with two-wheelers dominating the fleet (Clean Air Action Plan, Bhubaneswar, 2018).
- Bhubaneswar has the highest number of private cars (Clean Air Action Plan, Bhubaneswar, 2018).
- The city needs at least 22 consecutive air monitoring stations to statistically, spatially, and temporally represent the city's mix of pollution sources and levels (Urban Emissions, 2021).
- Open burning of trash is prevalent throughout the city. As cities generate more and more waste with limited ability to sort and dispose of it, stricter regulations are needed to address the problem (Urban Emissions, 2021).
- There are no official source distribution studies or source inventories to improve the accuracy of pollution profile assessments in Bhubaneswar (Clean Air Action Plan, Bhubaneswar, 2018).

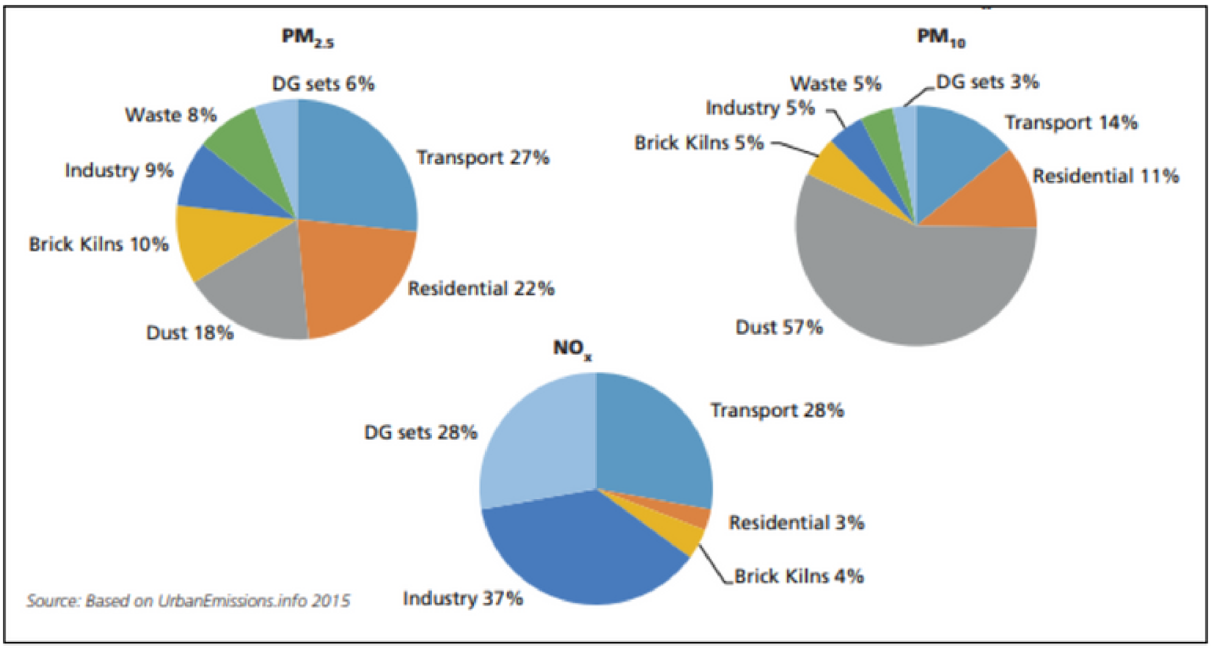


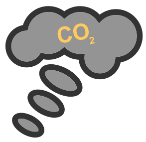
Figure: Bhubaneswar Emission inventory based on $PM_{2.5}$, PM_{10}, and NO_x

Monetary aid by the government under the wings of NCAP

The Central government has released a total of **₹74.48 crores** for the development of NCAP in Odisha during 2021-2022, where **₹27.61 crores** are solely reserved for the city of Bhubaneswar (*PRANA, CPCB, 2022*).

The action plan to abate air pollution in Bhubaneswar (Clean Air Action Plan, Bhubaneswar, 2018)

- To set up an adequate number of real-time automatic monitoring stations.
- Set up a daily air quality public information dissemination system based on National Air Quality Index and health advisory.
- Immediate implementation of newly devised emissions standards and siting policy for industries.
- Encourage industries to adopt clean technologies via the 'Star rating system'.
- Reducing tailpipe emissions through stricter emission standards, stringent emissions inspections, and phasing out older vehicles.
- Reducing urban emissions through improved public and non-motorized transportation systems.
- Traffic restrictions that reduce the need to use personal vehicles.
- Compact urban planning that reduces travel distances and total vehicle mileage.
- Replace traditional fuels, especially diesel, with cleaner fuels such as compressed natural gas (CNG), liquefied natural gas (LNG), and liquefied petroleum gas (LPG).
- Diesel generator sets and roof-top solar programme.



Clean Air Action Plan for Bhubaneswar

Why is Bhubaneswar under NCAP?

- Cuttack is identified as one of the non-attainment cities of Odisha.
- The main sources of air pollution in Cuttack are vehicular emissions, industrial emissions, and open burning of solid waste.
- A study conducted by the OSPCB in 2019 found that particulate matter (PM) levels in Cuttack were significantly higher than the national standards, with $PM_{2.5}$ levels being the highest.
- The ambient air quality does not meet NAAQS with respect to PM_{10} and $PM_{2.5}$.
- There are only 3 manual monitoring stations in Cuttack.
- The manual stations do not monitor all the criteria pollutants as set by the NAAQS.
- Air quality data for Cuttack is not available before 2014, as a result, it is not possible to assess the real-time daily trend that is needed for GRAP implementation.
- The government of Odisha has taken some measures to curb air pollution in Cuttack, including the implementation of graded response action plans, increasing green coverage, and promoting public transportation. However, more needs to be done to address the issue effectively.

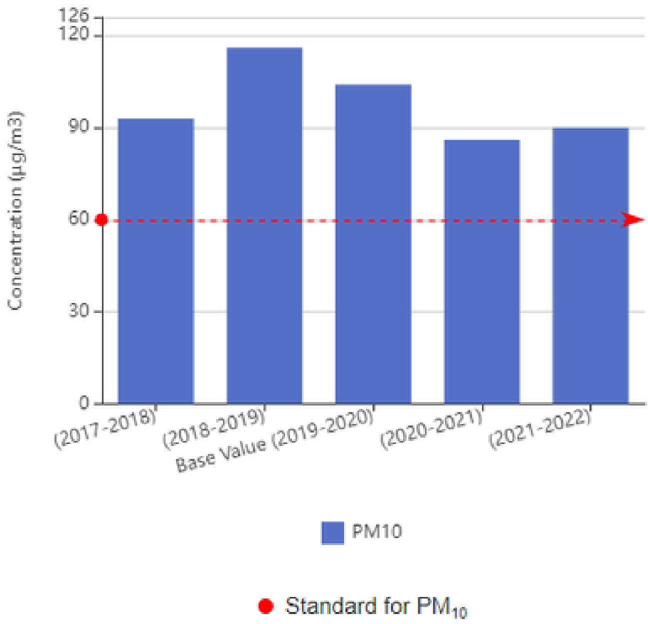


FIGURE: PM_{10} TREND OF CUTTACK SINCE 2017 SOURCE OF IMAGE: NATIONAL CLEAN AIR PROGRAMME, CENTRAL POLLUTION CONTROL BOARD, GOVERNMENT OF INDIA

Monetary aid by the government under the wings of NCAP

The Central government has released a total of **₹74.48 crores** for the development of NCAP in Odisha during 2021-2022, where **₹27.61 crores** are solely reserved for the city of Cuttack (PRANA, CPCB, 2022).

The action plan to abate air pollution in Cuttack

- Two real-time monitoring stations are to be set up in Cuttack (Clean Air Action Plan, Cuttack, 2018).
- To implement a graded response action plan, it is important to develop the ability to forecast pollution. This will require monitoring weather data (Clean Air Action Plan, Cuttack, 2018).
- The OSPCB should conduct a source apportionment and emissions inventory study to identify the sources of pollution and quantify their emissions throughout the seasons (Clean Air Action Plan, Cuttack, 2018).
- A daily air quality public information dissemination system should be established based on the National Air Quality Index and health advisory (Clean Air Action Plan, Cuttack, 2018).
- In addition, the SPCB website should be developed to report daily and annual data for all pollutants and pollution forecasting, and local media should be used to spread information (Clean Air Action Plan, Cuttack, 2018).
- Research studies, including emission inventories, source apportionment, health impact studies, exposure impacts, carrying capacity assessment of air shed, regional impacts, hot spot assessments, and other relevant studies may be conducted to refine and improve the action plan (Clean Air Action Plan, Cuttack, 2018).
- In 2022, the target was revised to reduce PM pollution levels by 40% by 2026 (Urban Emissions, 2023).

- Research studies, including emission inventories, source apportionment, health impact studies, exposure impacts, carrying capacity assessment of air shed, regional impacts, hot spot assessments, and other relevant studies may be conducted to refine and improve the action plan (Clean Air Action Plan, Cuttack, 2018).
- In 2022, the target was revised to reduce PM pollution levels by 40% by 2026 (Urban Emissions, 2023).

Below are some recommendations and way forward for the NCAP policy tracker-

RECOMMENDATIONS

- NCAP needs to be promoted on a larger scale to raise awareness about the boons of the programme.
- Modification of policies and setting up new CAAQMS monitoring stations are necessary.
- Non-government bodies and stakeholders need to be motivated to join hands with NCAP.

WAY FORWARD

- Acknowledgment of the worsening ambient air quality by the state government and stringent application of laws.
- Complying with the policies set by NCAP will help Cuttack to come out of the impending doom of air pollution.
- Increase awareness of the hazards of air pollution amongst the common public to aid the success of NCAP.

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