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Clean Air Action Plan for **Ramgarh**

Clean Air Action Plan for Ramgarh

Center for Study of Science, Technology and Policy
April 2023

Designed and edited by CSTEP

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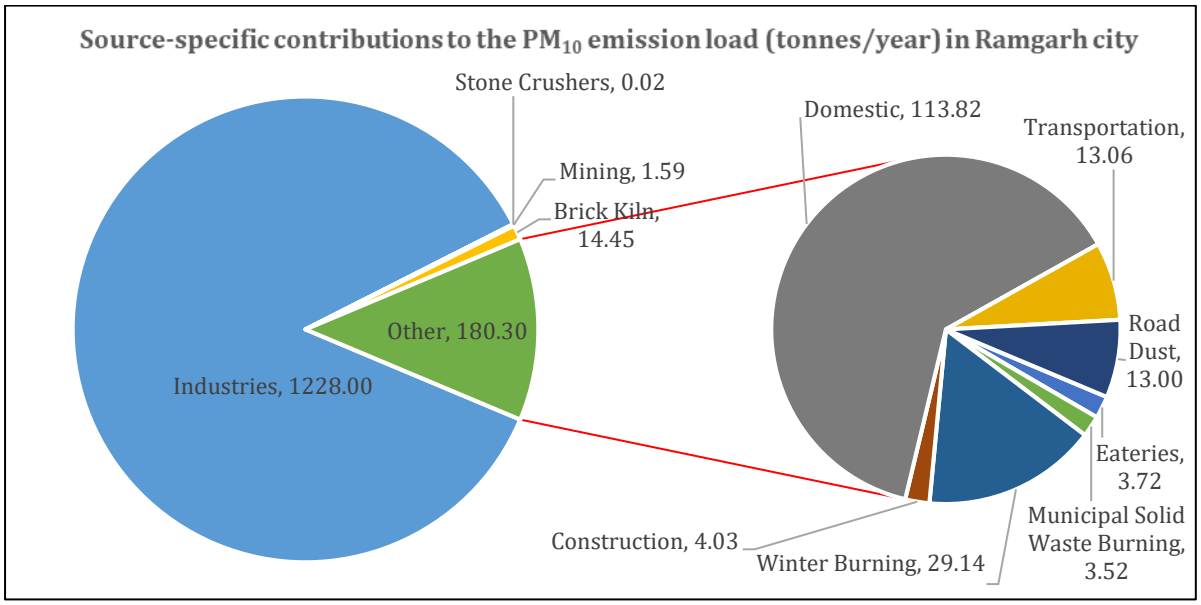
Executive Summary

In 2019, the Ministry of Environment, Forest, and Climate Change (MoEFCC) under the Government of India launched the National Clean Air Programme (NCAP), which proposes strategies to reduce air pollution in several cities in India. In Jharkhand, only Dhanbad, a non-attainment city, and Ranchi and Jamshedpur, million-plus cities, are under the purview of NCAP. However, considering the importance of mitigating air pollution in several cities in the state, the government has identified multiple cities, including Ramgarh, to generate evidence on air pollution. In this context, we prepared the Ramgarh Clean Air Action Plan to identify major polluting sources and prioritise measures to control air pollution. Further, the pollution landscape in the city was examined and data were collected through multiple interactions with policymakers.

The emission inventory prepared for the airshed (31 km × 40 km) revealed the total PM_{10} emission load to be around 14425 tonnes/year in 2019. The emission inventory developed for the city revealed that the total PM_{10} emission load was 1425 tonnes/year in 2019 and is expected to reach 1930 tonnes/year in 2030. Owing to the presence of thermal power plants and several other industries, industries contributed to 87% of the total emission load; the other polluting sources in the city included domestic and transportation sectors and winter burning.



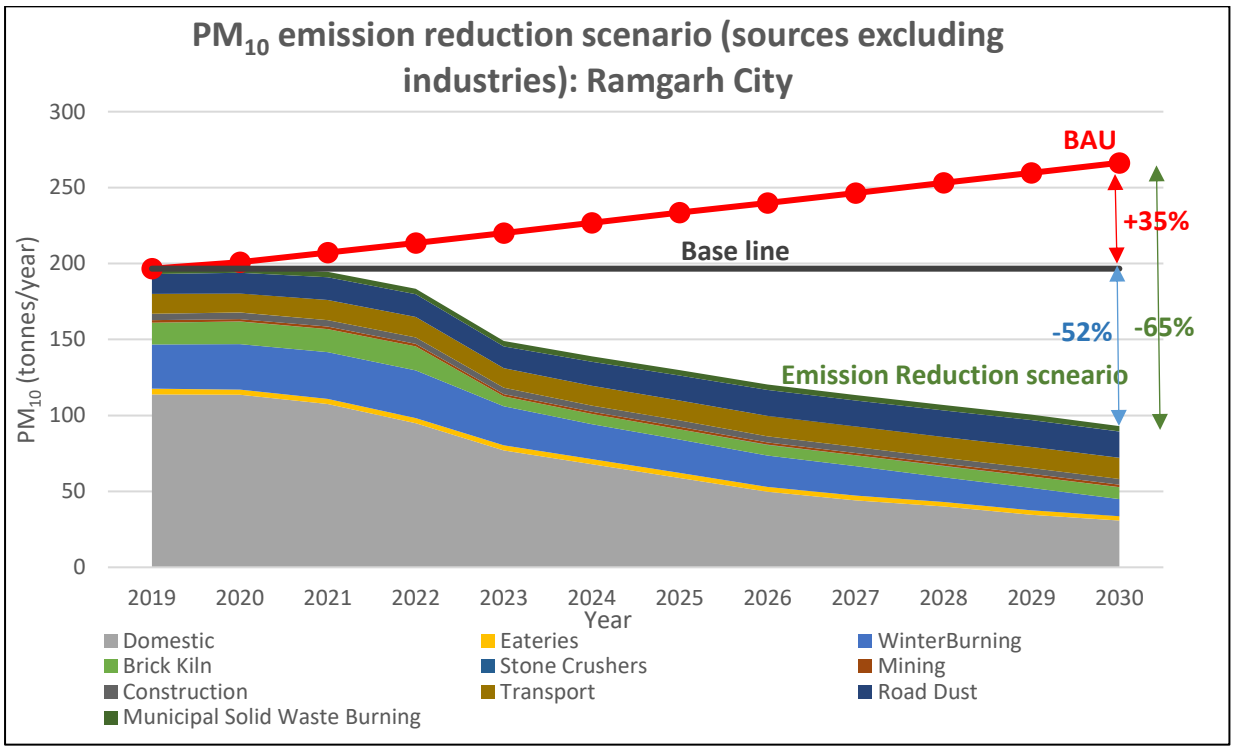
Based on the emission inventory results and existing pollution landscape, we identified the following source-specific control measures:

Industries: Almost all industries are dependent on coal for their production process. The government can incentivise industries transitioning to cleaner alternatives, such as piped natural gas or renewable energy sources, and adopting energy-efficient technologies to reduce their energy consumption.

Domestic: To promote the use of clean cooking fuel in households and reduce indoor air pollution, the government can set up additional liquefied petroleum gas (LPG) distribution centres and facilitate door-to-door delivery of LPG cylinders.

Transportation: Vehicles used within industrial premises should be compliant with pollution regulatory norms. Additionally, the government should encourage the adoption of electric vehicles by providing incentives for the purchase of electric vehicles and setting up charging infrastructure. Public transportation systems like buses can also be shifted to run on cleaner fuels, such as CNG or electricity.

The study estimated that by implementing the suggested measures, the total PM_{10} emission levels can be reduced by 26% in 2030, with a 65% reduction in the contributions from sources other than industries. The same has been highlighted in the figure below.



The deterioration of air quality in Ramgarh will negatively impact the environment and local economy. Implementation of the Ramgarh Clean Air Action Plan will be an important step in mitigating air pollution in the city and reducing its impact on public health. The government should implement the suggested measures to encourage the switch to clean energy sources and adoption of clean technologies. Since Ramgarh is highly industrialised and the industries are expected to bear the cost of pollution control equipment, the government expenditure for implementing the proposed measures will be low, and for sectors other than industries, the government expenditure may be less than INR 50 crores. Thus, successful implementation of the plan can lead to significant improvements in air quality and quality of life for Ramgarh residents.

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Abbreviations

BAU	Business As Usual
BCR	Benefit–Cost Ratio
CAAP	Clean Air Action Plan
CNG	Compressed Natural Gas
CPCB	Central Pollution Control Board
DPF	Diesel Particulate Filter
EI	Emission Inventory
EVs	Electric Vehicles
FAME	Faster Adoption and Manufacturing of Electric Vehicles
JSPCB	Jharkhand State Pollution Control Board
LPG	Liquefied Petroleum Gas
MoEFCC	Ministry of Environment, Forest, and Climate Change
NCAP	National Clean Air Programme
NOx	Nitrogen Oxides
PM	Particulate Matter
PNG	Piped Natural Gas
PUC	Pollution Under Control
SOx	Sulfur Oxides
TEA	Techno-Economic Assessment
TPP	Thermal Power Plant
UDHD	Urban Development and Housing Department

1. Introduction

Jharkhand has seen tremendous economic growth over the past two decades owing to its rich mineral resources. It is amongst the top states in India in terms of extraction of mineral resources. Several iron, steel, coal, and power industries established in the state have led to significant economic growth. However, this rapid growth in industrialisation and migration of labour has significantly damaged Jharkhand's environment. Particularly, air pollution is a key environmental concern. The Central Pollution Control Board (CPCB) and the Ministry of Environment, Forest and Climate Change have identified Dhanbad as a non-attainment city and Ranchi and Jamshedpur as million-plus cities under the National Clean Air Programme. Respective city action plans along with micro action plans have been prepared for these cities, and implementation of measures to control air pollution has been initiated. However, multiple cities in the state are heavily industrialised and affected by rising air pollution levels, e.g., Ramgarh, which has several coal-based thermal power plants and industries. As a result, the Jharkhand State Pollution Control Board (JSPCB) has identified Ramgarh as one of the most polluted cities in the state. Accordingly, a clean air action plan for Ramgarh has been prepared in this study.

1.1. Ramgarh: An Overview

Ramgarh, a cantonment town situated in the heart of Jharkhand, had a total population of 1,08,167 in 2019 (Town sanitation plan, 2019). The city has witnessed significant changes over the past decade in terms of build-up area. Figure 1 depicts the land use/land cover changes between 2007 and 2018 in Ramgarh district (Jha et al., 2021). There is a clear indication that mining and other industrial activities significantly increased in the city. The mining area increased by 5 times between 2007 and 2018. Considerable reduction in forest area and fallow land was also observed during the same period. These changes would have had a significant impact on environmental degradation in the region.

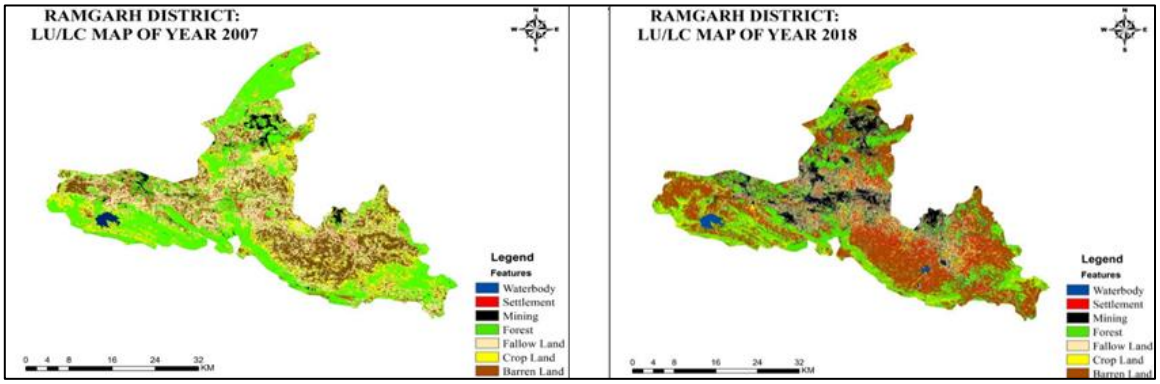

Figure 1: Land use/land cover change between 2007 and 2018: Ramgarh District

1.2. Need for the study

Despite the tremendous changes observed in the city in the past decade, issues related to air pollution have not been given much focus. The city does not have any air pollution monitoring station, and no studies focussing on air pollution have been conducted so far. Thus, a basic understanding of the sources of air pollution and potential control measures will be key in shaping the policy landscape related to air pollution control.

1.3. Scope of the study

The main objective of the study was to prepare a clean air action plan based on the evidence generated from the emission inventory (EI). Based on the EI, the study identified control measures, their associated costs, and strategies that the city should adopt. However, the targets and strategies suggested in the plan are based on the current infrastructural landscape of the city and might be reshaped based on their feasibility upon interaction with the district administration of Ramgarh and various departments of the Government of Jharkhand.

1.4. Structure of the Report

Section 2 of this report describes the EI of the city. Section 3 describes the determinants considered to frame the control measures and identified control options. Section 4 of the report describes the methodology adopted for performing the techno-economic analysis and the results. Section 5 discusses the key recommendations for the city.

2. EI: Ramgarh

The total PM_{10} sectoral emission in Ramgarh was estimated for the base year 2019 based on surveys, primary data collected from line departments, and secondary data. For the detailed methodology, refer to the report 'Air Pollution Emission Inventory for Six Cities in Jharkhand' (CSTEP, 2023). Given Ramgarh is a heavily industrialised area, emissions from industries contribute significantly to the total pollution load of the city, followed by the usage of coal in eateries and the domestic sector. Transportation and road dust are other sectors that contribute to the total emission load of the city.

Figure 2 presents the spatial distribution of the PM_{10} emission load across the considered airshed (an airshed is defined as a geographical area that has a major impact on a city's air pollution levels). It can be observed that the most heavily polluted areas are located outside the city boundary. This can be attributed to the presence of several industrial pockets outside the city area.

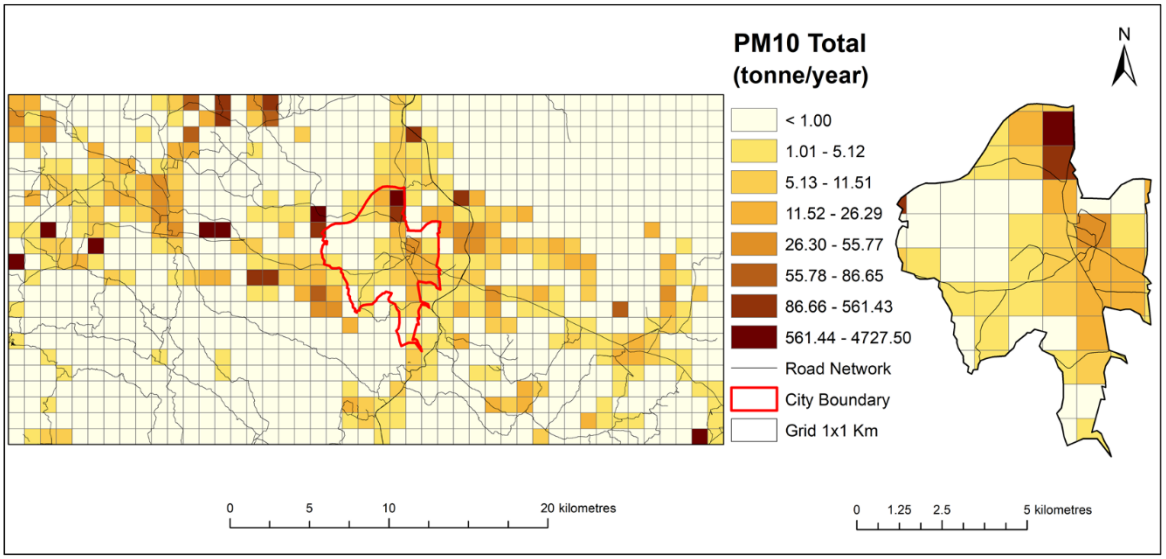

Figure 2: Spatial distribution of PM_{10} emissions

Figure 3 presents the total PM_{10} emissions at the city level. The total PM_{10} emission load in Ramgarh in 2019 was estimated to be 1425 tonnes/year. Industries contributed to around 86% of the total emission load, followed by the domestic sector, winter burning (burning of solid fuel during winters), and the transportation sector.

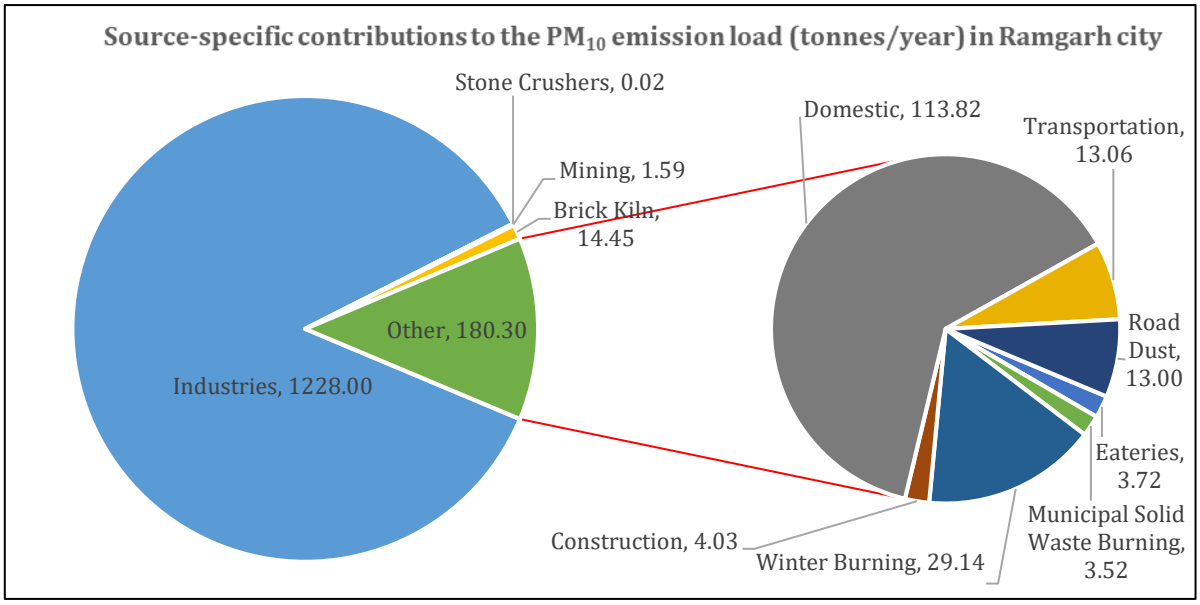

Figure 3: PM_{10} emission load (tonnes/year) at the city level in 2019

Figure 4 presents the percentage share of various sectors (excluding industries) to the total PM_{10} emissions at the city level. The domestic sector (58%) contributes significantly towards the pollution load. Winter burning contributes around 15% owing to heavy use of solid fuel during the winter season, followed by road dust, transportation, and brick kilns (each contributing 7%).

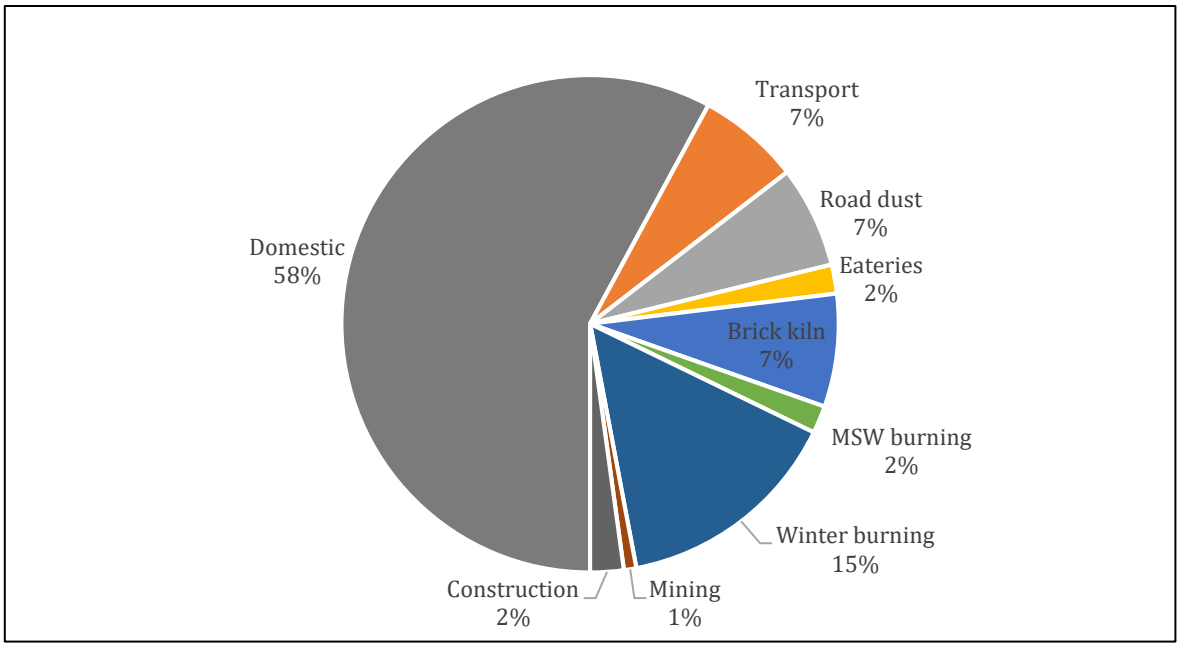

Figure 4: Sectoral share of PM_{10} emissions (excluding industries)

3. Source-Specific Control Measures

Air pollution in Ramgarh can be primarily attributed to the presence of heavy industries, including thermal power plants, iron and steel industries, and cement plants. Other sources including usage of coal, tailpipe emissions, presence of brick kilns, and stone crushers contribute to the total pollution load in the city. To improve the pollution scenario in the city, adopting a cross-sectoral approach is essential. Here, several sector-specific control measures have been listed considering the current pollution levels and policy landscape in the city. Determinants considered for each sector are listed below:

Industries: Type of industries, fuel and technology used, CPCB categorisation, and existing pollution control norms.

Transportation and road dust: Registration details, age of vehicles, industrial transport vehicles, road condition, modal share, road pavement details, congestion levels etc.

Domestic sector: Availability of coal, liquefied petroleum gas (LPG) penetration rate, and socio-economic conditions

Eateries: Availability of coal, footfall of hotels, and LPG availability

Waste burning: Waste generation amount, collection and segregation efficiency, and treatment capacity of the city

Winter burning: Availability of coal, usage of wood, and climatic conditions

Construction and demolition dust: Existing regulations and construction practices

Multiple interactions with the line departments were also organised to understand the planned infrastructural changes in the city. The identified list of control measures is provided in Table 1. Detailed targets and strategies specific to Ramgarh are discussed in the sections below.

Table 1: Air pollution control measures for Ramgarh

Sl. No	Sectors	Action points	Technology/Infrastructure Requirement (TR/IR)/Method (M)	Implementation Agency
1	Industry	Adopting new technologies for brick kilns	TR: Adopting zigzag technology	Jharkhand State Pollution Control Board (JSPCB) Department of Industries (Jharkhand)
		Shifting brick kilns outside the city	M: Finding an alternate location to shift the industries	
		Implementing the following measures and ensuring their functional efficiency at mining and stone crushing units: 1. Use of dust control equipment such as multi-cyclone dust collectors and baghouse filters	M: Audit systems	

Sl. No	Sectors	Action points	Technology/Infrastructure Requirement (TR/IR)/Method (M)	Implementation Agency
		2. Building enclosures around process equipment and boundary walls 3. Use of water sprinklers at crushing operations and along the roadside 4. Water sprinkling on stockpiles and on haulage roads 5. Use of covered conveyor belts 6. Development of a Green Belt 7. Use of nozzle sprays		
		Strict enforcement of pollution control equipment such as scrubbers, baghouse filters, electrostatic precipitators, low NOx burners, dry SOx removal system, cyclone cleaners, and dry or wet electrostatic precipitators in feasible iron and steel plants	M: Incentivise industries that install pollution control equipment	
		Implementing the following measures in cement plants: 1. Ensure that electrostatic precipitators, baghouse filters, and scrubbers are installed and operational at maximum efficiency. 2. Ensure that all pollution control norms are followed in mining and at the raw material preparation stage. 3. Incentivise the plants to shift to clean fuel	M: Incentivise industries that install pollution control equipment M: Audit Systems	
		Shifting towards cleaner fuel and advanced technologies	TR: Feasible technologies	
		Random auditing of industries and online reporting of pollution parameters	M: Audit systems	

Sl. No	Sectors	Action points	Technology/Infrastructure Requirement (TR/IR)/Method (M)	Implementation Agency
		Ensuring online emission monitoring systems are operational	M: Audit systems	
		Shifting polluting industries outside the city limit	M: Policy changes	
2	Power Plant	Strict enforcement of Central Pollution Control Board (CPCB) emission rules and installation of pollution control devices	M: Audit systems M: Study to determine the feasibility of installation of pre-, post-, and in-combustion pollution control equipment as recommended by the CPCB M: Reduce dependency on coal as a primary fuel	JSPCB
3	Domestic and Eateries	Introduction of advanced chulahs	M: Incentives to people switching to advanced chulahs	Department of Food, Public Distribution and Consumer Affairs, Government of Jharkhand
		Easy accessibility of LPG	M: Increase in LPG penetration rate and subsidised cylinders	
		Restrict supply of coal	M: Enforce a ban on sale of coal by unauthorised vendors	Ramgarh Nagar Parishad - Urban Development and Housing Department (UDHD)
4	Transportation	Increasing the use of electric/compressed natural gas (CNG) buses for public transportation	IR: Introduction of low-fare buses IR: EV stations/CNG stations	Transport Department (Jharkhand)
		Introduction of E-rickshaws and making provisions to replace older two-stroke autos with electric/CNG autos	IR: Scrapping centres, EV charging stations/CNG stations	
		Pollution under control (PUC) check every 6 months	IR: Infrastructure setup to check and maintain PUC	
		Incentivising the use of cleaner fuels for private transportation: electric and CNG vehicles	TR: Proper infrastructure to increase the adoption rate of cleaner fuels	

Sl. No	Sectors	Action points	Technology/Infrastructure Requirement (TR/IR)/Method (M)	Implementation Agency
		Installation of diesel particulate filters (DPFs) in diesel vehicles	M: Installing DPFs in trucks	
		Capacity building programmes to adopt new policies and technologies	M: Conduct regular awareness campaigns and capacity building exercises on new policies and technologies	
		Monitoring of vehicles used in industries	M: Ensure all vehicles used in industries are registered and monitored for pollution IR: Clear guidelines on the type of vehicles that can be used in industries	
		Restriction on plying of older (15+) commercial vehicles	M: Ban entry of trucks older than 15 years	Traffic Police
		Phasing out of older commercial vehicles	IR: Policy changes	
		Proper traffic management	IR: Policy changes	
		Ban on carriage transport during peak hours (8:00–9:30 AM and 5:00–7:00 PM)	IR: Policy changes	
		Checking on fuel adulteration	M: Audit systems	Ramgarh Nagar Parishad - UDHD
		Efficient parking facilities near hotspots	M: Improvement of the infrastructure at hotspots M: A detailed technical study must be conducted to ensure the proper utilisation of full road width and to identify parking spots	
5	**Road and Construction Dust**	Introduction of mechanical sweepers	IR: Purchase of equipment	Ramgarh Nagar Parishad - UDHD
		Pavement of roads and filling potholes	IR: Purchase of equipment	
		Transport of construction materials using covered vehicles	M: Audit systems	
		Covering of construction sites	M: Audit systems	
		Strict enforcement of CPCB guidelines for construction	M: Audit systems	

Sl. No	Sectors	Action points	Technology/Infrastructure Requirement (TR/IR)/Method (M)	Implementation Agency
		(use of green screens, side covering of digging sites, etc.)		
		Mandating the facility of tar road inside a construction site for movement of vehicles carrying construction material	M: Policy changes	
		Creating green buffers	IR: Purchase of new equipment	
6	**Solid Waste Management**	Increase waste management capacity of Ramgarh Nagar Parishad to increase collection and segregation efficiency	M: Addition of tippers, waste collection machines etc.	Ramgarh Nagar Parishad - UDHD
		Increase waste treatment capacity by setting up 1) composting plants and 2) dry waste collection centres	IR: Set up new treatment plants	
		Create separate zones for handling composting as well as construction and demolition waste and dry waste	IR: Set up new treatment plants	
		Identify garbage burning hotspots and conduct regular audits	M: Policy changes	
7	**Others**	Installation of continuous ambient air quality monitoring stations	IR: Identify locations and set up monitoring stations	JSPCB
		Launch public awareness campaigns to control air pollution	M: Policy changes	JSPCB
		City-wise limit on coal use	M: Policy changes	JSPCB

4. Techno-economic assessment (TEA) of control measures

Information on the benefit–cost ratio (BCR) and implementation feasibility of the proposed control measures will be crucial for policymakers to make informed decisions. Moreover, pollution reduction targets can be achieved quickly by allocating funds on the basis of the BCR. The TEA is a method for analysing the control options in terms of technical and economic feasibility. The technical feasibility analysis determines if a particular technology can be implemented in the city, and the economic analysis helps identify the control options that require less resources. The assessment results of control measures considered using TEA have been discussed in the following sections.

4.1. Transportation

In a previous study, Pietrzak, K. and Pietrzak, O. (2020) emphasized that improvements in public transportation could reduce the number of private vehicles on road, ultimately resulting in reduced pollution levels. As per the records of the transportation department for the base year 2019, around 34 buses were active in the city, with the public heavily relying on autos and personal vehicles (two-wheelers). A transportation survey was also conducted to understand the vehicle characteristics. Owing to Ramgarh being an industrialised area, the number of trucks and vehicles used to move goods was high. The following control measures are suggested to help reduce emissions from the transportation sector.

Control measure 1: Increasing the use of electric/compressed natural gas (CNG) buses for public transportation

The total number of buses required for the city was estimated using the framework suggested by CPCB.

$$Number\ of\ buses\ required = 0.3 * Population \div 1000 \quad (1)$$

As per Equation 1, the city would need around 35 buses. Despite the presence of a sufficient number of buses to cater to the public needs, adoption rates were low and most of these buses were old and ran on diesel. The city administration should conduct proper mobility studies to identify transportation routes and introduce low-fare public transportation modes. As electric and CNG buses generate less emissions and have a lower total cost of ownership than diesel buses (CSTEP, 2019), the government should consider promoting the use of electric or CNG buses over conventional ones. Table 2 provides the detailed assumption and emission reduction potential of this control measure.

Control measure 2: Replacing older two-stroke autos with E-rickshaws/CNG autos

As per our estimate, around 1466 autos older than 10 years were active in the city. However, even with a low fraction of these older autos, the amount of pollutants generated would be enormous. Considering approximately 1000 E-rickshaws were registered in 2017 (as per the Vahan Database), it would be feasible for the city administration to replace the older autos with newer E-rickshaws using the current infrastructure, as the environmental cost of diesel autos is more than that of electric and CNG ones (CSTEP, 2019). Table 2 describes the assumption cost and emission reduction potential of this control measure.

Control measure 3: Installation of diesel particulate filters (DPFs) in diesel vehicles

Mining and rapid industrialisation have raised the number of trucks operating in the city, ultimately increasing the emission of pollutants harmful to human health. These vehicles run on diesel and emit more than any other transportation modes. Installation of DPFs in trucks could control emissions by up to 90% (CSTEP, 2019). Factors such as the capital cost of the filter, maintenance facilities, and age of trucks were considered to evaluate suitable options. Since DPF installation is not economically beneficial for truck owners, the government should bear the capital cost of these filters. Trucks older than 10 years could be considered for DPF installation. Table 2 explains the detailed assumption and emission reduction potential of this control measure.

Control measure 4: Better pollution under control (PUC) check infrastructure and management

Rogers et al. (2002) indicated that with an effective and efficient PUC system, the level of pollution from the automobile sector could be decreased. As per the CPCB requirement, the city would need only seven PUC centres; however, as of 2019, there were around 20 PUC centres functioning in the city. Hence, no additional PUC centres would be required. The city should enforce strict PUC norms, and all vehicles used within industry premises should be monitored for pollution. Linking PUC with motor insurance could be one method to ensure that all vehicles have a valid PUC certificate. Further, periodic inspection of petrol bunks to monitor fuel adulteration should be conducted.

Control measure 5: Reducing congestion

The roads of Ramgarh are typically narrow, with the city still undergoing development; thus, congestion could become a serious threat in the near future. To avoid congestion, the district administration and traffic police should start implementing measures such as enforcing a ban on carriage trucks during peak hours and building parking bays at hotspots to enable public parking at designated spaces. Figure 5 shows some vehicles being parked on the sides of a narrow road, which forces other vehicles to move at a slower speed. Policies such as diverting heavy vehicles during peak hours, creating designated parking spaces, promoting public transportation, and encouraging lane discipline could help the city manage congestion.

Figure 5: Narrow roads of Ramgarh

Table 2: Transportation sector: target, strategies and associated costs

Control Measure	Assumption	Infrastructure requirement and immediate targets	Cost (INR Lakhs)	PM_{10} Emission reduction (from the transportation sector)
Increasing the number of electric or compressed natural gas (CNG) buses in the public modal share	Diesel buses will be replaced with electric/CNG vehicles. Cost of electric buses: INR 80 lakhs Cost of CNG buses: INR 60 lakhs	Number of charging stations: 2 Target number of buses (by 2024): 10 CNG buses and 10 electric buses Responsible department: Transportation	1202	1.53%
Replacing older two-stroke autos with E-rickshaws or CNG autos	Autos older than 10 years will be replaced. Incentives: 30,000 INR	Number of scrapping centres: 2 All 10-year-old vehicles to be replaced by 2024 Responsible department: Transportation	450	1.33%
Installation of diesel particulate filters (DPFs) in diesel vehicles	Trucks older than 10 years will be retrofitted with DPFs Incentives: 30,000 INR	Number of trucks to be targeted by 2024: 1171 Responsible department: Transportation	351	26.96%
Promoting electric and CNG vehicles for private transportation	Promote the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme	At least 5% of vehicles running in Ramgarh to be based on electric/CNG by the target year 2024. Responsible department: Transportation	130	0.61%
Other key policies include a) mandating vehicles used in industrial areas to have periodic pollution checks, b) phasing out of vehicles older than 15 years, and c) building parking lots and establishing better traffic management systems.				

4.2. Industry

The industrial sector is a major polluting source in the city. Figure 6 below highlights the locations of industrial clusters around the city. Heavy usage of coal in these industries is one of the primary reasons for high emissions from the sector. The government should focus on incentivising industries that switch to clean fuel or adopt clean technologies.

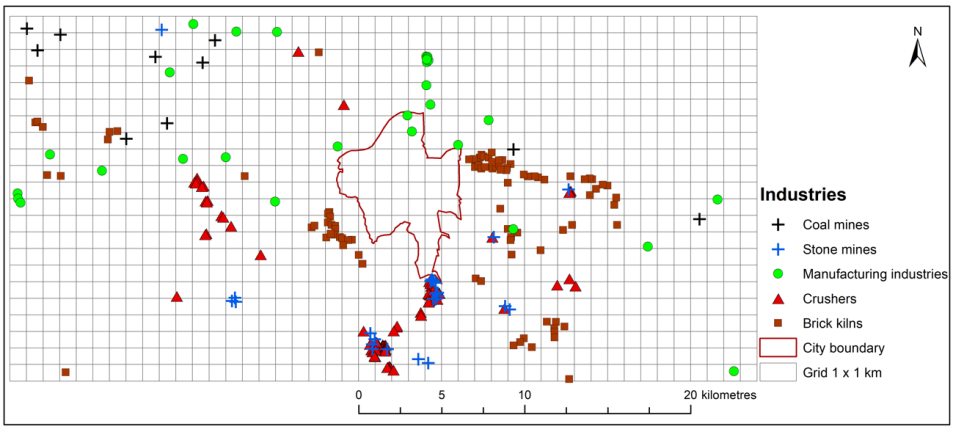

Figure 6: Industrial locations in and around Ramgarh

The total energy consumption of stack-based industries based on their fuel usage is shown in Figure 7. Coal is primarily used in most industries because of its easy access. Control measures that the city should adopt are listed below.

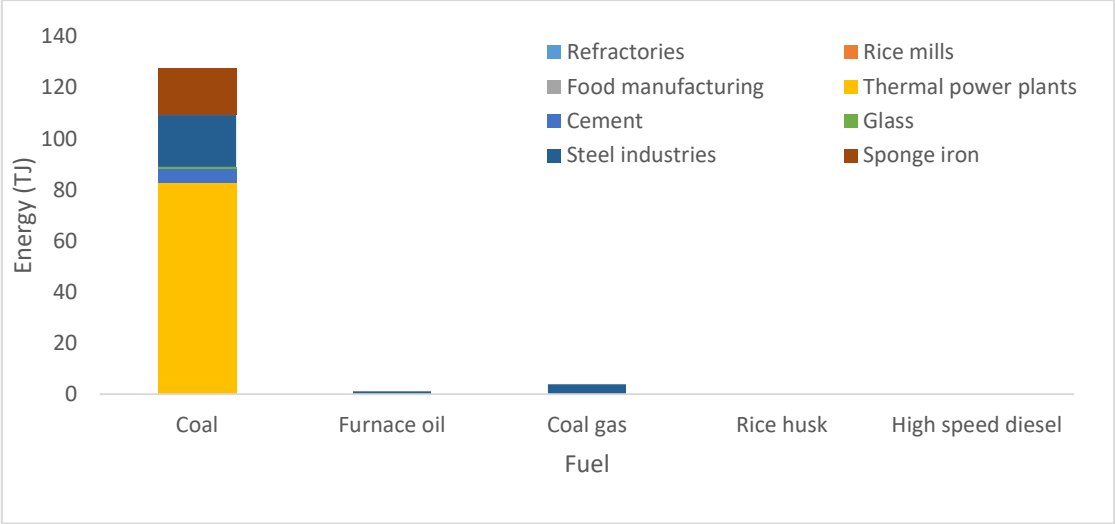

Figure 7: Total energy consumption of the industries based on their fuel usage

Control measure 1: Encouraging brick kiln owners to shift to the zigzag technology

Only two brick kilns are present within the city, but 93 brick kilns are being operated in the air shed area. As per the JSPCB 2021 report, around 80% of the kilns that are operational in Jamshedpur use traditional technology. The scenario is similar in Ramgarh. Converting these traditional technologies into the zig-zag technology will be beneficial to both the brick kiln owners and the environment. The estimated cost incurred to make the transition is INR 25 Lakhs per kiln (CSTEP, 2019), with a payback period of only 6 months. If all brick kilns in the area shift to the advanced technology, the total emission load from brick kilns could be reduced by 32%. The kilns owners will also benefit financially in terms of better-quality bricks and reduced fuel consumption.

Control measure 2: Strict implementation of norms suggested for stone crusher units.

The JSPCB has set clear guidelines, such as use of water sprinklers and construction of boundary walls, paved roads, covered storage units, and green covering, to be followed at mining and stone crusher units. More inspections that are regular should be conducted at these sites to ensure that all norms are followed.

Control measure 3: Use of advanced technologies and cleaner fuels

Figure 8: Visible black smoke from an industrial unit at Ramgarh

Thermal power plants, iron and steel industries, and cement industries significantly contribute to the total pollution load in the city. Most widely used fuel in these industries is coal. As the technology used in these industries is not disclosed to the public, it is difficult to suggest technology options. However, measures should be taken to encourage these industries to switch from coke to CNG/piped natural gas (PNG) and ensure that pollution control devices are installed and operational. Measures such as fuel gas desulphurisation, selective catalytic reduction, and use of electrostatic precipitators should be adopted in thermal power plants after a proper feasibility study.

Online emission monitoring systems should be enabled at all industrial units, and strict action should be taken against units that fail to comply with the standards.

4.3. Domestic sector and eateries

Easy availability of coal and low LPG penetration rate (less than 35%) are two of the main reasons for emissions from the domestic and eateries sector. The domestic survey conducted in the city revealed that more than 50% households and eateries were dependent on coal for their cooking and heating needs. Increase in LPG usage and reducing the use of coal will be key in reducing the total emission load of the domestic sector. The following control measures must be adopted for reducing emissions from the domestic sector.

Control measure 1: Increasing the number of LPG connections in the low-income strata

In terms of the domestic sector, the LPG penetration rate in Ramgarh is very low compared with that in other cities in India. According to PPAC (2016), high initial cost and recurring cost are key barriers for LPG adoption; other barriers include waiting time and safety awareness in Jharkhand. Hence, to increase the LPG penetration rate in the city, the government should consider subsidising the cost of the connection and cylinders. Ramgarh would need 100% LPG coverage to improve the quality of life of its citizens. As 100% coverage might not be possible in the near term, the city could aim to achieve the target of 62% (similar to Sahibganj's LPG penetration rate). Table 3 provides the detailed targets and assumption of this control measure.

The survey conducted on eateries at Ramgarh revealed that both categories of restaurants (footfall < 100 and footfall = 100–500) were heavily dependent on coal/solid fuels for their cooking needs. All restaurants with footfall > 100 should be mandated to switch to LPG.

Control measure 2: Promoting the use of advanced chulahs

Even if the city achieves 62% LPG penetration, some households might still be dependent on solid fuels. By promoting the use of advanced chulahs, the quantity of solid fuel being used can be considerably reduced. Table 3 denotes the strategies and targets to be adopted in this regard.

Table 3: Domestic sector and eateries: targets, strategies and cost requirement

Control measure	Assumption	Immediate Targets	Cost (INR Lakhs)	Emission reduction potential (domestic sector and eateries)
Increasing the number of LPG connections	In the domestic sector, the city will achieve a similar LPG penetration rate as that of Sahibganj. Subsidies will be given for new connections and cylinder refills.	*Domestic sector:* 62% LPG penetration rate by 2024; Additional LPG refuelling centres: 6 *Eateries:* All hotels with footfall > 100 to use only LPG Responsible department: Food and civil services department	New connections: 376 Subsidised refills per year: 225	Domestic sector: 40% Eateries: 51%
Promoting the use of advanced chulahs	All households with no LPG connection to switch to advanced chulahs	*Domestic sector*: 38% households to adopt advanced chulahs *Eateries:* Eateries with footfall < 100 should adopt advanced chulahs Responsible department: Food and civil services department	Incentives to households or eateries for using advanced chulahs: 331	Domestic sector: 21% Eateries: 16%

4.4. Open waste burning

As per the data provided by the Ramgarh Nagar Parishad, the city generates around 30 tonnes per day of waste, with a collection efficiency of 90% and a segregation efficiency of 60%. Around 27 tonnes of waste is collected, while 18 tonnes of waste is treated. A detailed project report has also been prepared to increase the treatment capacity of the city. The city has good collection levels and sufficient treatment capacity. However, the only setback is the segregation level, which can be increased through awareness programmes and policies such as denying collection in cases where the waste is not segregated at source. In addition, the Ramgarh Nagar Parishad should identify locations where garbage burning is common and strictly monitor and control burning in those areas.

4.5. Winter burning

Generally, the temperature at Ramgarh drops below 10°C during winter months. During this period, people rely on coal and biomass to fulfil their heating needs. Winter burning contributes to around 2% of the total pollution load. Uncontrolled burning of coal could result in increased emissions, although banning coal burning during winter may be inconvenient to the public. Thus, guidelines on restriction of coal usage, extinguishing the fire, and clearing of waste should be implemented to control the amount of coal being used.

4.6. Road and construction dust

Introduction of mechanical sweepers and pavement of roads are key measures to control emissions from this sector.

As per the data provided by the Transportation Department, the total road length that would require mechanical sweeping is only 50 km. Considering the capacity of a mechanical sweeper and its run time, the city would need one mechanical sweeper.

Other control measures that should be implemented include pavement of roads and maintaining pothole-free roads, while ensuring that vehicles carrying dust or other materials are covered.

Figure 9: Uncovered Construction sites

Since the city is still in a developing stage, construction activities are common. Thus, it is important that all guidelines such as covering construction sites, building paved roads within construction sites, among other National Green Tribunal rules are appropriately implemented to control dust resuspension at these sites.

4.7. Capacity building

Ramgarh does not have any air pollution monitoring station, and no studies have been conducted so far to determine air pollution levels in the city. To generate evidence, the JSPCB should set up monitoring stations, conduct source apportionment/EI studies to understand the emission sources, enable air quality forecasting, and build capacity for the regional pollution control board of Ramgarh.

4.8. Hotspot-specific interventions

This study also identified areas where a particular sector was a key contributor to the pollution load (Table 4). The line departments can target these hotspots to reduce air pollution levels in the city.

Table 4: Pollution hotspots in Ramgarh

Area	Polluting activities	Measures
Mahatma Gandhi Chowk, Jhanda Chowk, MES Colony, and Saudagar Mohalla	Transportation and road dust-related emissions	Road pavement and usage of a mechanical sweeper
Patratu, Chaingara, Argada, Rauta, and Kamta	Thermal power plant and other industries	Ensure implementation of all CPCB norms in industries
Kaitha, Gobardarha, Piri, and Masmohana	Brick kilns	Promote advanced brick kiln technology

Area	Polluting activities	Measures
City: Patratu, Goriyaribag, and Block Chowk are the major sites within the city	Domestic emissions: Usage of solid fuel Municipal waste burning	Usage of advanced chulahs and increase in LPG penetration
Airshed: Bhurkunda, Gegda, Suddi, Piri, and Chitarpur		Identify garbage burning hotspots
Subhash Chowk and Bijulia	Eateries: Usage of solid fuel	Promote the use of LPG and chulahs
Garsula, Kurkuta, Gidi, and Religara and Dari coal mines	Mining	Ensure implementation of all CPCB norms in mining areas

4.9. Scenario Analysis: before vs after implementation of control measures

The study projected emissions till 2030 based on the sectoral growth rates, such as number of vehicle registrations and population growth, as well as existing and upcoming policies such as EV policy and solid waste management plans. Industrial growth was based on the information provided by the Department of Industries, Jharkhand. Figure 10 presents the projected emission load for the city till 2030. In the Business As Usual scenario, the total PM_{10} emissions will reach 1930 tonnes/year in 2030, a 35% increase from the base year 2019.

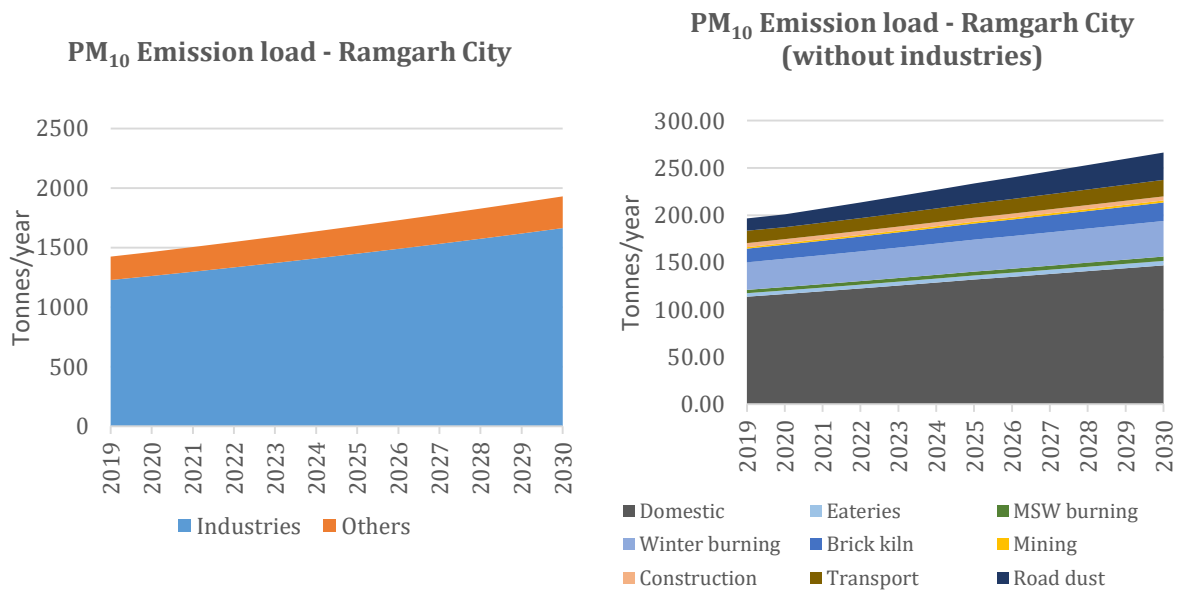

Figure 10: Total PM_{10} Emissions

The impact of individual interventions on the air quality is described in the previous section. Considering air pollution is a cross-sectoral issue, implementation of the suggested measures across all sectors will be necessary to improve the overall air quality. To understand the outcomes of these measures, the current study considered that the suggested changes were implemented during the base year and were projected till 2030 with the same growth rate. The considered interventions with a high BCR are mentioned in Table 5 below.

Table 5: Interventions considered for emission reduction scenario

Transportation	
• Introduction of low-fare public transportation options. • Replace diesel buses with electric or CNG buses	• Replace 10-year-old two-stroke autos with E-rickshaws/CNG-based autos • Install DPFs in 10-year-old trucks
Industries	
• All brick kilns to operate using the zigzag technology • Shift in fuel usage (pet-coke or coal to piped natural gas)	• Implement all CPCB norms
Domestic sector and eateries	
• LPG penetration rate: 62% • Adoption of advanced chulahs: 38% households	• Reduction in the use of coal • All restaurants with footfall of 100 or more to switch to LPG
Solid waste burning and winter burning	
• Complete ban on open waste burning	• Controlled winter burning
Road and construction dust	
• One mechanical sweeper	• End-to-end pavement of major roads

Using this combined intervention, the city could reduce the total PM_{10} emission load to 1426 tonnes/year, a 26% reduction from the current scenario wherein no interventions are adopted. Figure 11 highlights the reduction in the total pollution load in Ramgarh.

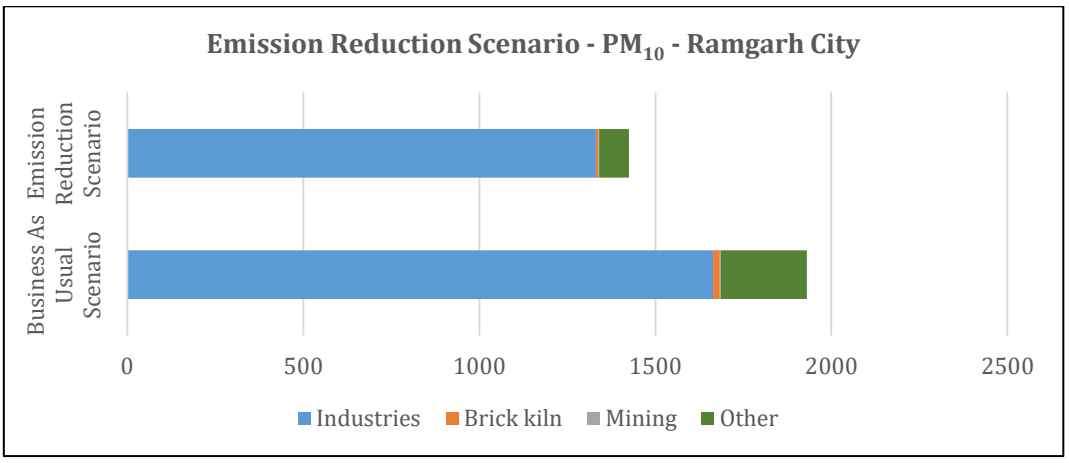

Figure 11: Changes in PM_{10} levels before and after implementation of interventions

Since a significant portion of the emission load could be attributed to industries, the effects of interventions without industrial emissions were also analysed. The study found that there could be an emission reduction of 65% in PM_{10} emissions from sectors other than industries in 2030. Figure 12 represents the change in PM_{10} emission load (excluding industries) before and after the implementation of the suggested control measures.

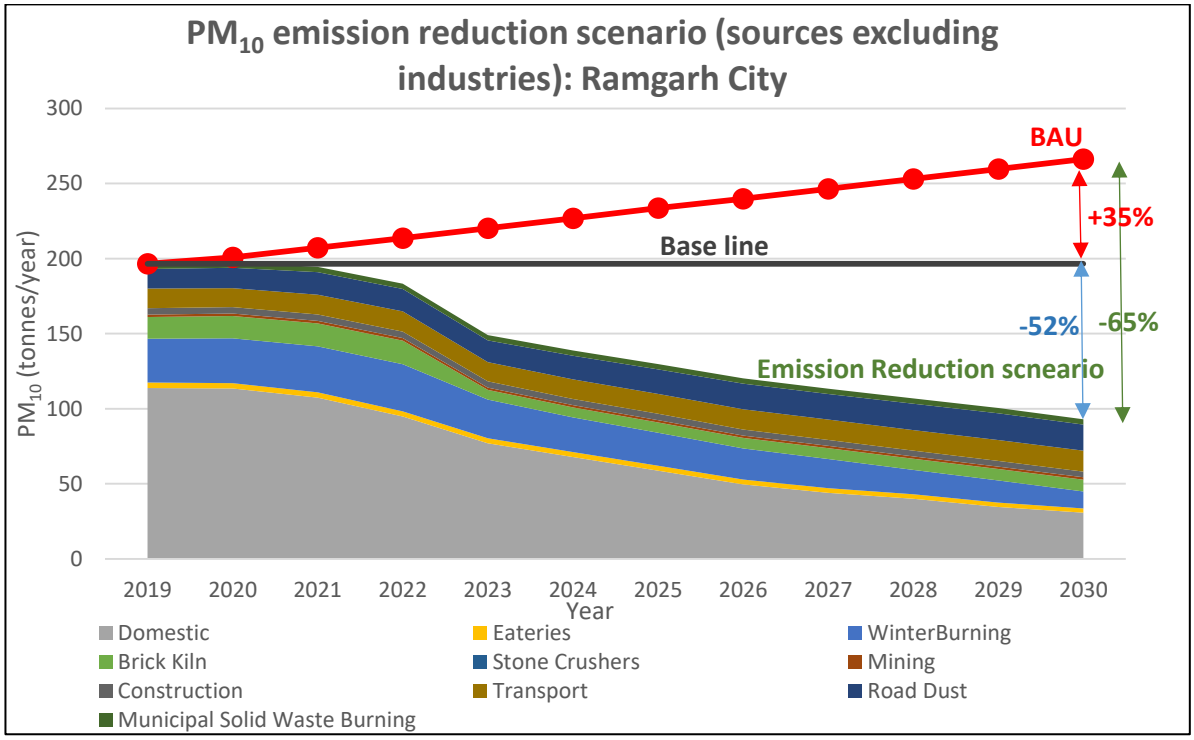

Figure 12: PM_{10} emission reduction (excluding industries)

5. Recommendations

Usage of coal, presence of heavy industries, and transportation are key emission sources in Ramgarh. The city could ensure a drastic reduction in emissions by focussing on these key areas. Listed below are few of the key interventions that the city could adopt:

1) Reduction in coal usage

Considering coal is abundantly available in Ramgarh, the following measures are recommended to reduce emissions:

a. encourage industries to shift from coal/pet-coke to PNG
b. enable controlled burning during winter season
c. enforce a limit on coal usage

2) Ensure heavy vehicles are compliant to pollution norms:

All vehicles used within industrial premises should be registered and monitored for pollution. Heavy diesel trucks should be installed with DPFs.

3) Easy accessibility to clean fuels for domestic and eateries sector

The LPG penetration rate in Ramgarh is amongst the lowest in India. Additional LPG distribution centres that enable door-to-door LPG delivery will ensure reduction in the use of solid fuel.

4) Promoting electric/CNG vehicles for public and private transportation

The city is yet to build a comprehensive mobility plan. Inclusion of vehicles that run on electric/CNG should be a priority while considering any policy measures.

5) Capacity building

a. Conduct studies such as source apportionment/EIs and set up monitoring stations to generate evidence
b. Arrange training workshops for pollution control board experts
c. Implement an online monitoring tool to monitor pollution levels near industries.

6. Way forward

Industrial growth plays an important role in the economic development of a city. Generally, in a city or state rich in mineral resources, a large number of industries and manufacturing units are set up. Thus, it is very important for the government to focus on negative externalities that may arise due to these developments. Economic advancement at the cost of people's health is not sustainable in the long run. In this regard, JSPCB is moving in the right direction by not only focussing on non-attainment cities but also on cities with potentially high air pollution emissions.

To better evaluate pollution levels in a city, generating scientific evidence is key. Hence, city officials should focus on installing continuous ambient air quality monitoring stations and conduct critical scientific studies, such as source apportionment studies. Based on the collected evidence, city officials can focus on the suggested measures and devise plans to control air pollution.

Further, to ensure that the implemented plan is effective, support from line departments, the public, and various other stakeholders will be crucial. Conducting capacity building exercises for government officials working on ground, setting up project management units to track implementation progress, and creating awareness on air pollution issues will ensure synergy among all stakeholders to achieve desired results.

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