FINAL REPORT

Envisioning a Sustainable Bakery Industry for Mumbai

Examining the Current Fuel Use in Mumbai's Bakeries and Formulating Policies for the Adoption of Sustainable Fuels

Bombay Environment Action Group (BEAG)

2023 - 2024

Team:

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Foreword

Mumbai, like many major cities in the world, is grappling with the issue of pollution control. With my 38 years of experience in pollution prevention and control, I cannot stress more on the importance of taking initiative to understand and address the various sources that contribute to air pollution. This is exactly the work that has been taken up by the Bombay Environmental Action Group (BEAG) in this report.

The Bakery industry stands as a testament to both culinary heritage and evolving environmental challenges. It has been reported to contribute around 5% of the total emissions in Mumbai. This report has taken up the challenge to envision a sustainable Bakery Industry for Mumbai. It delves into the need to transition from carbon-intensive fuels to cleaner, more sustainable energy sources.

This report covers a comprehensive analysis and strategic approach towards transitioning Mumbai's bakery sector to sustainable fuel practices. Chapter 1 introduces the role of BEAG and the National Clean Air Program (NCAP), setting the context for the study. Chapter 2 provides an in-depth examination of the air pollution status on global, national, and local (Mumbai) levels, including various news articles. Chapter 3 classifies bakeries and details the general baking process. Chapter 4 outlines the study's objectives and methodology. Chapter 5 presents detailed observations and discussions from the field survey, including ward-wise and zone-wise distribution of bakeries, fuel choices, and their economic and health impacts. Chapter 6 focuses on policy formulation.

The comprehensive examination of the current fuel usage in Mumbai's bakeries reveals a heavy reliance on wood-fired ovens. This dependence on wood, while steeped in tradition, poses significant environmental and health risks due to its high carbon footprint and associated air pollution. The study presents a clear, data-driven analysis of fuel consumption patterns, barriers to adopting cleaner alternatives, and the economic implications of various fuel options.

The project's methodology, divided into three distinct phases—data collection, mapping, and analysis—offers a thorough approach to understanding the complexities of fuel use in the bakery sector. The findings highlight the economic advantages of wood and scrap wood, despite their environmental drawbacks, and underscore the need for a strategic shift towards cleaner fuels like electricity, LPG, and PNG.

Addressing the obstacles faced in this transition, the study identifies high initial costs, limited awareness, and logistical challenges as key barriers. To overcome these issues, the project advocates for comprehensive policy development, financial incentives, and collaborative efforts between government bodies, bakery owners, and other stakeholders.

By laying out clear policy needs and proposing actionable solutions, this study aims to pave the way for a sustainable transformation in Mumbai's bakery industry. It serves as a vital resource for policymakers, industry leaders, and environmental advocates committed to reducing the sector's environmental impact while preserving its rich tradition.

I am pleased to see the report, which has the potential to be a game-changer if implemented. As we look towards a future where sustainability and tradition coexist harmoniously, this project represents a crucial step towards a cleaner, greener Mumbai.

Dr. Jitendra Swarup Sharma
President,
Indian Association for Air Pollution Control

CONTENTS

LIST OF FIGURES AND TABLES

TABLES	

LIST OF ABBREVIATIONS

RTI	Right to Information	**SCM**	Standard Cubic Meter
BEAG	Bombay Environmental Action Group	**BBA**	Bombay Bakers Association
GST	Goods and Services Tax	**PIO**	Public Information Officer
CPCB	Central Pollution Control Board	**KML**	Keyhole Markup Language
MPCB	Maharashtra Pollution Control Board	**GPS**	Global Positioning System
$PM_{2.5}$	Particulate Matter 2.5	**GIS**	Geographic Information System
PM_{10}	Particulate Matter 10	**WHO**	World Health Organization
MMR	Mumbai Metropolitan Region	**INR**	Indian Rupee
AQI	Air Quality Index	**VOC**	Volatile Organic Compounds
MoEFCC	Ministry of Environment, Forest and Climate Change	**UF**	Urea Formaldehyde
NCAP	National Clean Air Programme	**PF**	Phenol-formaldehyde
USD	United States Dollar	**PU**	Polyurethane
CAGR	Compound Annual Growth Rate	**FPUF**	Flexible Polyurethane Foam
GDP	Gross Domestic Product	**CO**	Carbon Monoxide
BMC	Brihanmumbai Municipal Corporation	**CO2**	Carbon Dioxide
LPG	Liquefied Petroleum Gas	**CH4**	Methane
PNG	Piped Natural Gas	**HCN**	Hydrogen Cyanide
BPA	Bisphenol A	**PVA**	Polyvinyl Acetate
PCDD/F	Polychlorinated Dibenzo-p-dioxins Dibenzofurans	**PVC**	Polyvinyl Chloride
TPD	Ton Per Day	**BaP**	Benzo(a)pyrene
COPD	Chronic Obstructive Pulmonary Disease	**DG sets**	Diesel Generating sets
ECA	Essential Commodities Act	**HC**	Hydrocarbon
IIT	Indian Institute of Technology	**IMD**	Indian Meteorological Department
IoRs	Importer of Records	**ISRO**	Indian Space Research Organisation
MCGM	Municipal Corporation of Greater Mumbai	**MGL**	Mahanagar Gas Limited
MMR	Mumbai Metropolitian Region	**MSME**	Micr, Small and Medium Enterprises
NOx	Nitrogen Oxides	**PAH**	Polycyclic Aromatic Hydrocarbons
RTO	Regional Transport Office	**SOx**	Sulphur Oxides

SYMBOLS

$\mu g/m^3$: micrograms per cubic meter

CHAPTER 1: INTRODUCTION

Figure 1: Map of Mumbai with demarcated wards

Mumbai, one of the largest cities in India, faces considerable challenges in managing its environmental footprint. The rapid urbanization and industrialization in Mumbai have led to a surge in environmental concerns, in particular air pollution. Over the past ten years, Mumbai has experienced a notable change in its air quality scenario, primarily due to increased emissions from vehicles, industries, and construction activities. An annual average $PM_{2.5}$ concentration of about 63 micrograms per cubic meter (µg/m³), was noticed surpassing the World Health Organization's recommended limit of 10 µg/m³ (1). Recent data indicates that construction sites have emerged as the main source of pollution, followed by vehicle and industrial emissions. Air quality in Mumbai deteriorated steadily, with pollution doubling over the last five years where $PM_{2.5}$ levels surged by 54.2% between 2019 and 2020, with marginal drops in 2021 and 2022 but a significant spike of 42.1% in 2023 (2). The Air Quality Index (AQI) in Mumbai has consistently fluctuated between moderate to poor categories (150-200). The toll of air pollution has been substantial, with around 29,000 deaths in Mumbai by November 2023, costing approximately $2.9 billion in lost productivity (3).

While industries, construction and vehicular emissions are commonly recognized sources, the contribution of smaller-scale establishments such as bakeries often goes unnoticed. Bakeries in Mumbai contribute 3,271.3 kg/day (3.5%) of the PM load, 43.8 kg/day (0.5%) of the SOx load, 286.7 kg/day (0.2%) of the NOx load, 23,887.2 kg/day (15.9%) of the CO load, and 21,642.2 kg/day (25.4%) of the HC load to the city's total emissions from all sources. The incomplete combustion of solid fuels in bakeries, such as wood, leads to the production of methane (CH_4) and carbon dioxide (CO_2) along with other byproducts such as carbon monoxide (CO) and volatile organic compounds (VOCs). Studies have identified major pollutants emitted from bakeries as carbon monoxide (CO), hydrocarbons (HC), and particulate matter (PM_{10}) primarily from wood burning. The highest concentrations of PM_{10} were observed in wards A, E, G/N, and S (4).

Methane and carbon dioxide, both greenhouse gases, have an immediate impact on the microclimate. Just as a small disturbance can create ripples across a pond, even minor contributions to pollution can amplify into substantial impacts over time. Thus, addressing this often-overlooked sector is imperative to prevent it from becoming a major contributor to Mumbai's air pollution crisis.

1.1 ROLE OF BOMBAY ENVIRONMENT ACTION GROUP (BEAG)

Bombay Environment Action Group (BEAG)'s work in tackling air pollution in Mumbai began in the year 2014, in collaboration with NEERI and IIT. Bakeries fueled by wood fire, located amidst residential areas, were identified as one of the contributing sources of pollution. In 2015, the MPCB constituted the "Study Group to frame suitable Environmental Guidelines for Bakery Industries in the state of Maharashtra', Bombay Environment Action Group (BEAG) being a member started interacting with various Bakers Associations, MPCB, MCGM, IIT Mumbai, Oven manufacturing Units and collated a lot of information.

Through comprehensive research and advocacy, Bombay Environment Action Group (BEAG) facilitated the establishment of environmental guidelines for bakeries across Maharashtra. Armed with data obtained through RTIs and extensive stakeholder consultations, Bombay Environment Action Group (BEAG) raised awareness about the prevalence of wood-fired bakeries and prompted regulatory action from MPCB. Their persistent advocacy resulted in streamlined permit processes for bakeries by MCGM, promoting cleaner and more sustainable baking practices.

Although various suggestions were put forth about bakeries switching to cleaner fuel, no actions were initiated to tackle the problem. The problem was also discussed in 2018 and recently in January 2023, wherein Bombay Environment Action Group (BEAG) presented the problems and solutions for enabling bakeries to switch to cleaner fuels. Though the suggestions were welcomed, no action was initiated further.

Subsequently, since 2023, Bombay Environment Action Group (BEAG) has been carrying out 'A study to assess bakery pollution contribution and its mitigation for Greater Mumbai'. This study aims to quantify pollution reduction, identify barriers, assess alternative fuel viability, and advocate for cleaner technologies.

1.2 NCAP

The Ministry of Environment, Forest and Climate Change (MoEFCC) initiated the National Clean Air Programme (NCAP) in January 2019 with the aim of enhancing air quality in 131 cities across 24 States/Union Territories. This program targets cities with poor air quality levels and those with populations exceeding one million. NCAP seeks to achieve a reduction of up to 40% in Particulate Matter 10 (PM_{10}) concentrations or attainment of National Ambient Air Quality Standards by 2025-26. Its objectives include improving the ambient air quality monitoring network, implementing timely measures to prevent and mitigate air pollution, and devising feasible management plans for pollution prevention, control, and reduction. Articles highlighting air quality (Figure 2) and particulate matter pollution (Figure 3 & 4) in these cities show the urgency and importance of these efforts.


Pollution More Than Double Over Last 5 Years In Mumbai, Study Shows

India News | Edited by Anindita Sanyal | Thursday November 2, 2023

October is the first of the winter months when air quality starts going south, and in Mumbai, the volume of pollutants has doubled between 2019 and 2023.

www.ndtv.com

Figure 2: News Article

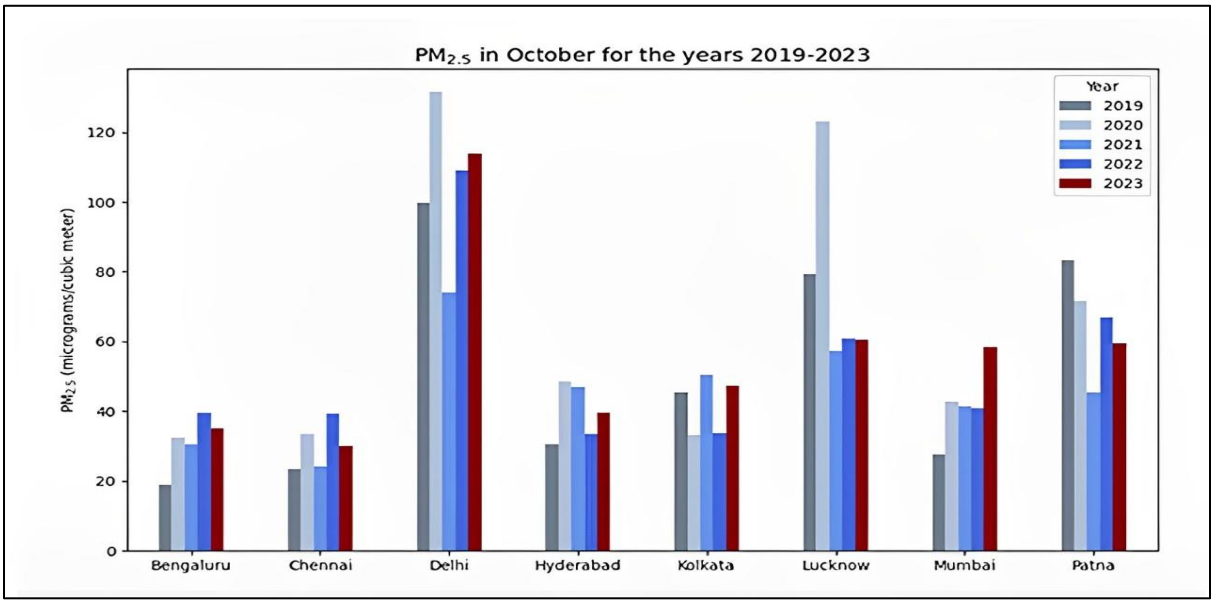

Figure 3: PM $_{2.5}$ values of major metropolises in India (2019-2023)

SOURCE: India News, November 02, 2023; A report by climate-tech start-up Respirer Living Sciences found Delhi, Mumbai, Hyderabad and Kolkata all exhibiting a rise in highly polluting PM (Particulate Matter) 2.5.

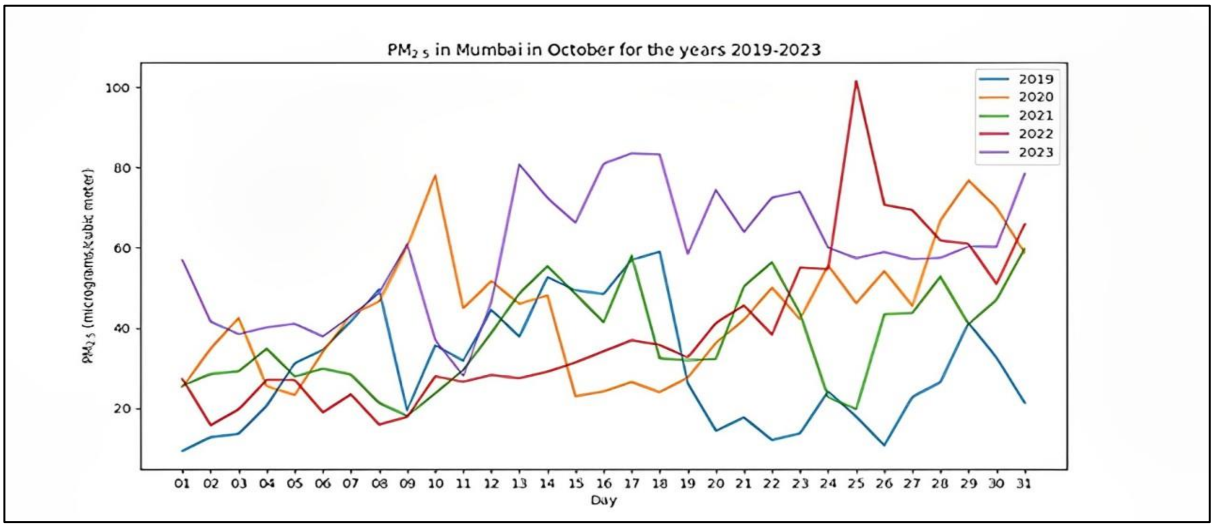

Figure 4: PM $_{2.5}$ in Mumbai in October (2019-2023)

SOURCE: India News, November 02, 2023; A report by climate-tech start-up Respirer Living Sciences found Delhi, Mumbai, Hyderabad and Kolkata all exhibiting a rise in highly polluting PM (Particulate Matter) 2.5.

CHAPTER 2: COMPREHENSIVE STATUS OF AIR QUALITY

Mumbai experiences air pollution from multiple sources (Figure 5) such as vehicles, construction, open burning, industries, eat outs, bakeries, crematoria, etc. Overall mixed sources and their impacts make it a complex problem to address. Though all of these sources need separate action plans that government agencies are addressing, the smaller sources remain unaddressed due to their meagre contribution. However, the smaller sources are the ones who in the local area can create significant local health impacts, if left without any remedies. For similar reasons, their mapping and detail plans are largely missing.

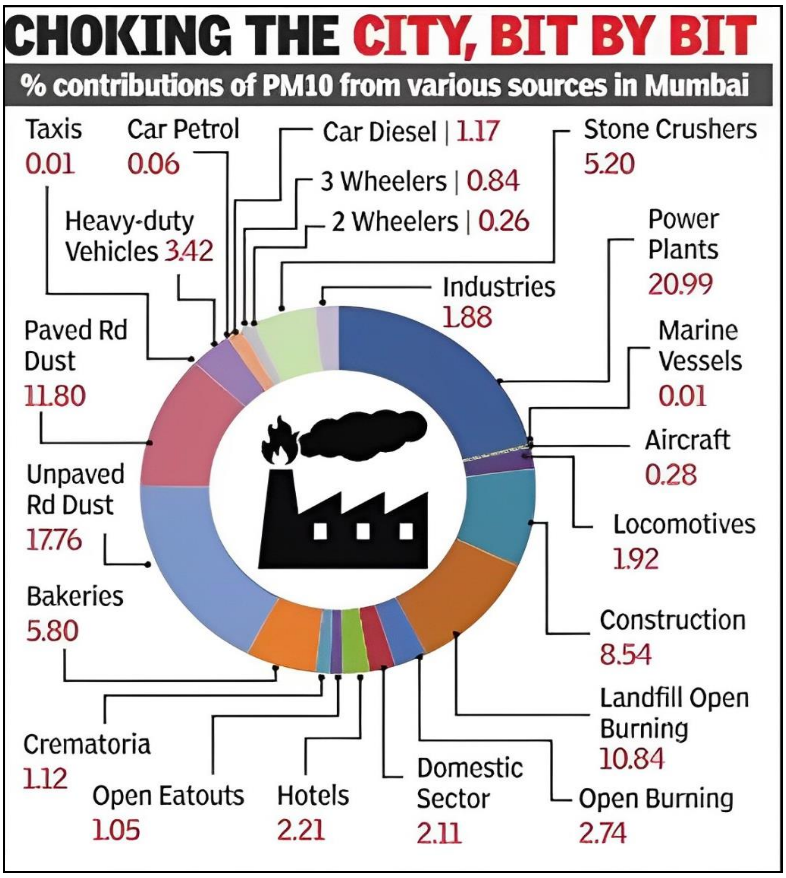

Figure 5: Sources of pollution in Mumbai

Source:http://timesofindia.indiatimes.com/articleshow/50156802.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

While studies on urban air pollution in Mumbai abound, few have specifically addressed emissions from bakery operations. Existing research primarily focuses on industrial and vehicular sources, leaving a gap in our understanding of emissions from smaller-scale commercial activities like bakeries. Despite their ubiquity, bakeries in Mumbai city lack comprehensive emissions mapping, hindering targeted mitigation efforts at the source itself. The absence of data on emission sources, quantities, and dispersion patterns limits policymakers' ability to formulate effective regulatory measures and capacitate stakeholders to implement sustainable practices.

2.1 GLOBAL SCENARIO OF AIR POLLUTION

The global air pollution index highlights the severe environmental impact of rapid industrial growth. As depicted in Figure 6, the average levels of $PM_{2.5}$ in major cities around the world are alarming, with Mumbai reaching 46.7 µg/m³—far exceeding the WHO guideline of 10 µg/m³. In 2021, 8.1 million people died worldwide due to air pollution-related diseases, with India accounting for one in four of these deaths. India (with 2.1 million deaths) and China (with 2.3 million deaths) together represented 55% of the global air pollution burden that year (5).

Economic growth and development mirrored in rapid urbanisation, rising disposable incomes, changes in consumer preferences, growth of retail formats, innovation, product diversification, and increased health consciousness have resulted in the expansion of not only the global bakery industry but also of its Indian counterpart. The value of the global bakery sector stood at USD 513.17 billion in the year 2023. The growth rate of this sector is projected at a Compound Annual Growth Rate (CAGR) of 6.7 percent between 2024 and 2032 (6).

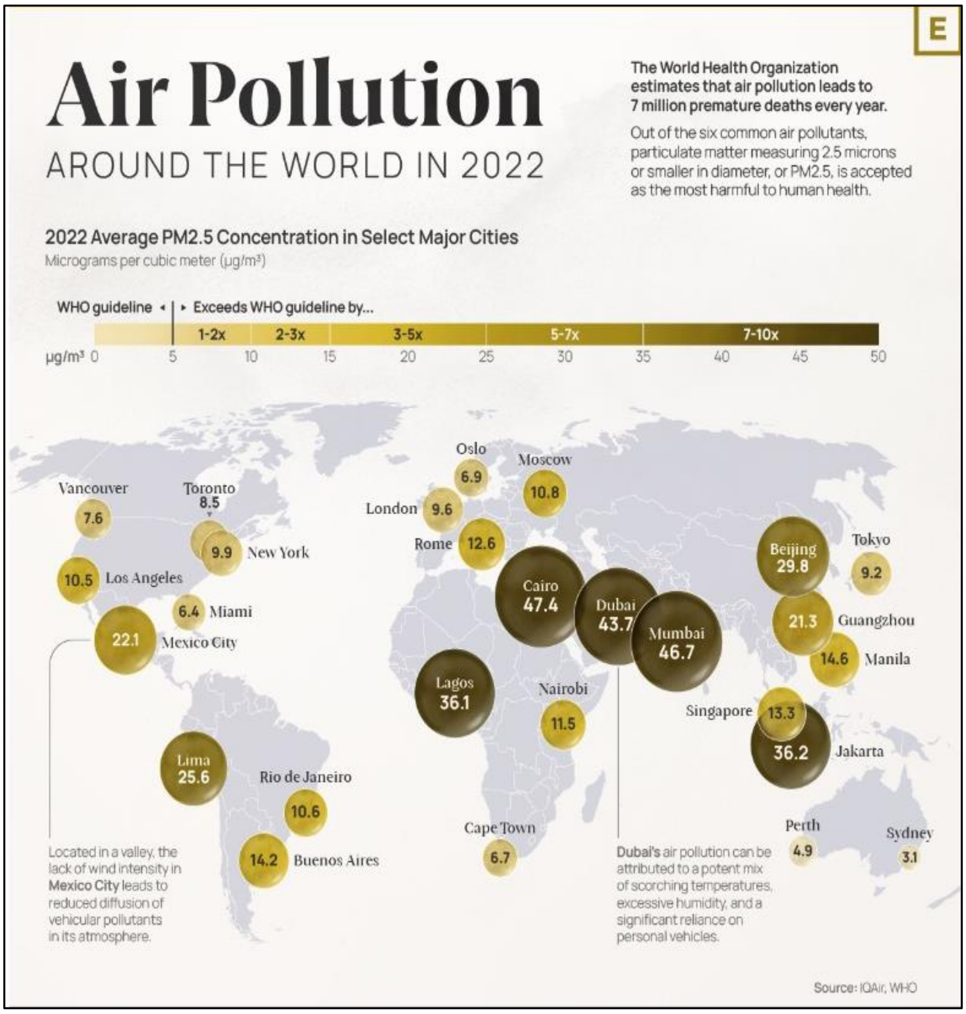

Figure 6: Global scenario of air pollution (PM* $_{2.5}$ *of selected cities)
Source: IQAir, WHO (ELEMENTSVISUALCAPITALIST.COM)

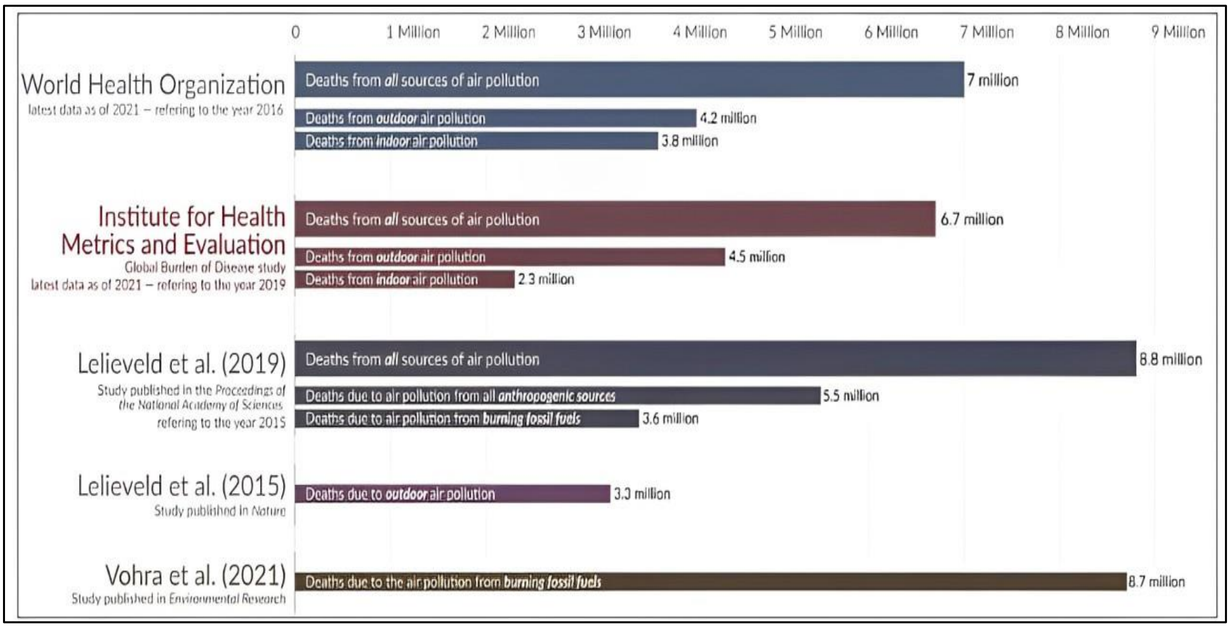

Figure 7: Different studies describing mortality rates due to air pollution

2.2 INDIAN SCENARIO

Figure 8 highlights the poor air quality in India by using color-coded circles, with many cities showing high AQI levels indicative of severe pollution. Air pollution has significantly impacted the burden of non-communicable diseases in India. Approximately 40% of deaths from heart disease, 33% of lung cancer deaths, 20% of type 2 diabetes deaths, 41% of stroke deaths, and 70% of COPD (chronic obstructive pulmonary disease) deaths in 2021 were linked to air pollution. The primary culprit is the microscopic $PM_{2.5}$, responsible for six out of every ten air pollution-related deaths worldwide (7). Various institutional studies and research underscore the profound impact of air pollution on global mortality rates, as illustrated in Figure 7 while Figure 9 highlights the mortality rate condition in India.

The Indian bakery industry has emerged as one of the largest segments in the country's food processing sector. There are over a million bakeries in the unorganised sector while over 2000 organised or semi-organized bakeries in India (8). Of the three million tonnes of bakery products manufactured in India, 1.3 million tonnes are accounted for by the organised sector while the remaining is produced by unorganised, small scale and local players (9). Having grown at a CAGR of over 15 percent in the past years, the market size of the bakery industry stood at USD 11.3 billion in 2022. Owing to the forecasted growth rate (CAGR) of 10.8 percent during 2023-28, the bakery industry is poised to reach USD 21.2 billion in value by 2028 (10). Conventional notions of economic growth and development are being increasingly replaced by concepts such as green growth and sustainable development to correct the myopia resulting from failing to take into account concerns of natural resource depletion and environmental degradation. This has implications for the growth of the bakery industry as well. The critical question that confronts the bakery sector is how will it sustain its growth trajectory while pursuing its green transition.

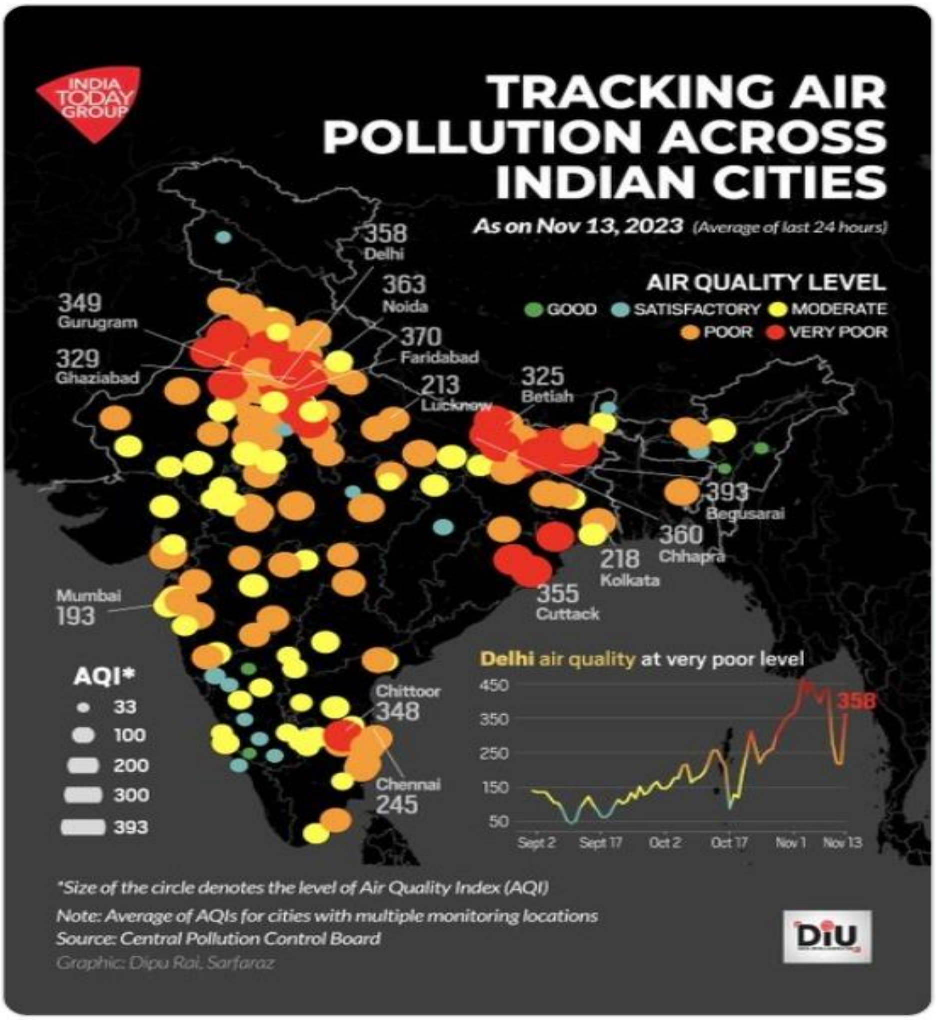

Figure 8: Indian scenario of air pollution
Source: https://images.app.goo.gl/EyQaFimkH616EVrE6

Printed from
THE TIMES OF INDIA

464 children die daily in India due to air pollution: Report

TNN | Jun 19, 2024, 09.09 AM IST

MUMBAI: Every day, on average, 464 children aged under 5 die in India reportedly due to air pollution-related causes, according to 'State of Global Air (SoGA) 2024' brought out by an US-based research organisation, Health Effects Institute (HEI). Across all age groups, the all-India toll stood at 2.1 million in 2021, it said.
The findings show air pollution is now second to hypertension as a death risk factor, beating tobacco and diabetes.

Figure 9: Indian mortality rate due to air pollution

2.3 MUMBAI SCENARIO

A significant fraction of the gains in India's GDP and its development translates into higher incomes and greater development for metros like Mumbai, contributing to an increase in air pollution. Figure 10 shows the annual average of $PM_{2.5}$ levels in Mumbai's wards from 2008-2019, showing an overall reduction in pollution but higher levels of $PM_{2.5}$. A corresponding rise in aggregate demand and consumption is reflected in the city's bakery sector as well. The number of bakeries in Mumbai, according to the BMC, is 560 while the bakeries' associations peg this number at 1500 (11). Increments in Mumbai's GDP and development have been followed by a rise in pollution. Bakeries have emerged as the third largest source (16 percent) of particulate matter PM_{10} in Mumbai (12). The oven is the primary source of emissions at a bakery. According to a survey, 67 percent of the bakeries use wood-fired ovens in Mumbai (11). Several studies (4) have highlighted the emissions arising due to the burning of wood and other fuel in bakeries which are shown in Tables 1 and 2 below:

Table 1: Fuel Type and respective emissions in kgs per day

Fuel Type	PM_{10} (kg/day)	$PM_{2.5}$ (kg/day)	SO_2 (kg/day)	NOx (kg/day)	CO (kg/day)	HC (kg/day)
Wood Burning	3,269.7	2,223.4	37.8	245.7	23,870.7	21,640.5
Diesel Burning	0.47	0.32	0.27	8.58	1.97	0.37
Electric Heating	0.0026	0.0017	5.5488	31.4160	14.3820	1.3260
LPG Burning	1.117	1.117	0.213	0.958	0.134	0.038

Table 2: Fuel Type and respective emissions in tonnes per year

Fuel Type	PM_{10} (tonnes/year)	$PM_{2.5}$ (tonnes/year)	SO_2 (tonnes/year)	NOx (tonnes/year)	CO (tonnes/year)	HC (tonnes/year)
Wood Burning	1194.21	811.59	13.81	89.71	8697.30	7886.33
Diesel Burning	0.17	0.12	0.10	3.13	0.72	0.14
Electric Heating	0.001	0.001	2.03	11.45	5.25	0.48
LPG Burning	0.408	0.408	0.078	0.350	0.049	0.014

The comprehensive status of air pollution is discussed in this chapter. Tables 1 and 2 compare the emissions from different fuel types, showing that wood burning has the highest PM_{10}, $PM_{2.5}$, CO, and HC emissions, making it the most polluting option. Diesel burning, while less impactful than wood burning, still contributes notable amounts of NO_x and CO. Electric heating has the lowest particulate emissions but higher NO_x and CO emissions than LPG burning. Though higher in emissions than electric heating, LPG burning has a more moderate impact than wood and diesel burning. $PM_{2.5}$, primarily from sources like wood burning, contributes significantly to global deaths from heart disease, lung cancer, diabetes, stroke, and COPD, underscoring its severe health impacts and the necessity for mitigation efforts.

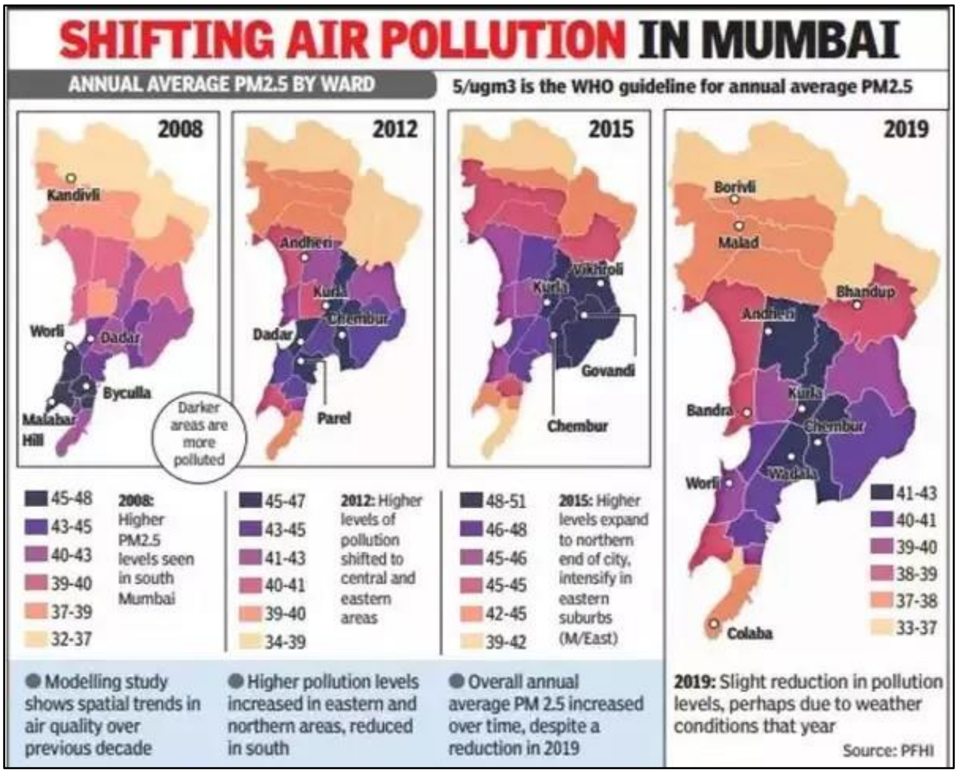

Figure 10: Mumbai scenario of air pollution

2.4 NEWS ARTICLES

Wood burning in bakeries and crematoria has been identified as a significant contributor to air pollution (Figure 11A). In response, the Maharashtra Pollution Control Board (MPCB) issued a circular on February 5, 2024, as part of the National Clean Air Programme (NCAP), aiming to address air pollution in the Mumbai Metropolitan Region (MMR) (Figure 11B). The circular outlines plans to curb the use of solid fuels, which are a major source of air pollution in the MMR. Figure 11 represents various news articles highlighting the surge in air pollution due to wood burning across Mumbai.

the AQI, particularly with re- lable is mostly observed to be tion plans. Upon NGT's direc- In case of sev

Survey: Wood burning at bakeries, crematoria contribute to toxic air

Prafulla.Marpakwar
@timesgroup.com

Pic used for representation only

Bakeries usually have 2 ovens and the average wood consumption per oven is 250kg/day

Mumbai: Besides construction sites and haphazard transportation of construction material and burning of garbage, a survey conducted by the Maharashtra Pollution Control Board (MPCB) has found that bakeries and crematoria too are contributing to the air pollution in Mumbai metropolitan region, owing to burning of huge quantity of wood.

Based on the primary survey estimates, it was found that 67% of the bakeries use firewood in ovens, and the rest use diesel and LPG. A very limited number of bakeries also use electric and PNG-run ovens.

According to BMC, there are about 560 bakeries operating in Mumbai, but the bakeries' association reports that the number is 1,500.

Wood burning is the main source of pollution from bakeries, which operate for 16 hours daily, and their peak business season is December-January.

The association informed BMC and MPCB that on an average, bakeries have two ovens and the average amount of wood consumption per oven is 250kg/day, while diesel consumption is 60 liters/day.

"Major pollutants from bakeries are CO, HC and PM10 due to wood burning, highest PM10 concentration was found in wards A (Colaba, Cuffe Parade, Nariman Point, [...]gate, Fort), E (Mazgaon, [...]a, Byculla), G-North (Dadar, Mahim, Shivaji Park) and S (Vikhroli, Bhandup). Large number of authorised as well as unauthorised bakeries are operating in Dharavi, Bandra and Khar," said the survey.

On crematoria, the MPCB report said that as per Hindu tradition, funerals are carried out primarily using wood. There are about 68 Hindu crematoria in the city, of which 53 are BMC-run — 42 crematoria use only wood for burning bodies and 11 are electrically operated — and 35 are operated by private agencies that use wood for cremation. The average wood requirement for each cremation, as per the primary survey and consultation with BMC officials, is 300kg. It appears that 20% of the bodies are cremated in the electric crematoria in wards where the facility exists and the remaining 80% at crematoria that use wood.

MPCB member secretary Avinash Dhakne said that it is high time for bakeries to switch to high-end ovens to avoid air pollution. So far, as air pollution from crematoria is concerned, Dhakne said it was a question of sentiments as many people prefer wood for burning of bodies.

Former MPCB member-secretary Dilip Boralkar, however, said that pollution from crematoria is incidental and not a regular issue. "Bakeries must shift to new technology in a time-bound period," Boralkar added.

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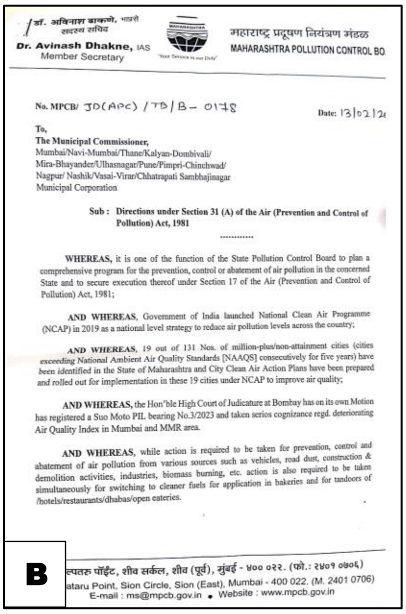

डॉ. अविनाश ढाकणे, भाप्रसे
सदस्य सचिव
Dr. Avinash Dhakne, IAS
Member Secretary

"Your Service is our Duty"

महाराष्ट्र प्रदूषण नियंत्रण मंडळ
MAHARASHTRA POLLUTION CONTROL BO

No. MPCB/ JD(APC) / TB / B– 0178 Date: 13/02/24

To,
The Municipal Commissioner,
Mumbai/Navi-Mumbai/Thane/Kalyan-Dombivali/
Mira-Bhayander/Ulhasnagar/Pune/Pimpri-Chinchwad/
Nagpur/ Nashik/Vasai-Virar/Chhatrapati Sambhajinagar
Municipal Corporation

Sub : Directions under Section 31 (A) of the Air (Prevention and Control of Pollution) Act, 1981

....

WHEREAS, it is one of the function of the State Pollution Control Board to plan a comprehensive program for the prevention, control or abatement of air pollution in the concerned State and to secure execution thereof under Section 17 of the Air (Prevention and Control of Pollution) Act, 1981;

AND WHEREAS, Government of India launched National Clean Air Programme (NCAP) in 2019 as a national level strategy to reduce air pollution levels across the country;

AND WHEREAS, 19 out of 131 Nos. of million-plus/non-attainment cities (cities exceeding National Ambient Air Quality Standards [NAAQS] consecutively for five years) have been identified in the State of Maharashtra and City Clean Air Action Plans have been prepared and rolled out for implementation in these 19 cities under NCAP to improve air quality;

AND WHEREAS, the Hon'ble High Court of Judicature at Bombay has on its own Motion has registered a Suo Moto PIL bearing No.3/2023 and taken serios cognizance regd. deteriorating Air Quality Index in Mumbai and MMR area.

AND WHEREAS, while action is required to be taken for prevention, control and abatement of air pollution from various sources such as vehicles, road dust, construction & demolition activities, industries, biomass burning, etc. action is also required to be taken simultaneously for switching to cleaner fuels for application in bakeries and for tandoors of /hotels/restaurants/dhabas/open eateries.

ल्पतरु पॉईंट, शीव सर्कल, शीव (पूर्व), मुंबई - ४०० ०२२. (फो.: २४०१ ०७०६)
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E-mail : ms@mpcb.gov.in • Website : www.mpcb.gov.in

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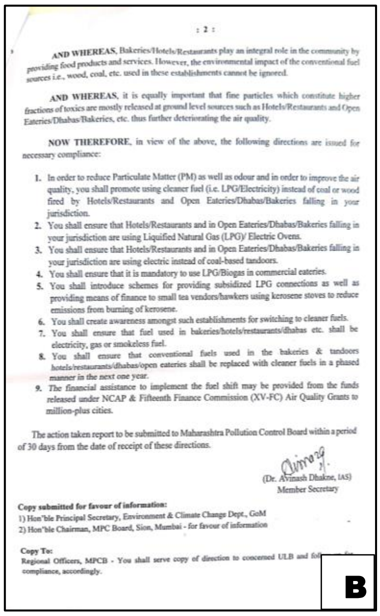


: 2 :

AND WHEREAS, Bakeries/Hotels/Restaurants play an integral role in the community by providing food products and services. However, the environmental impact of the conventional fuel sources i.e., wood, coal, etc. used in these establishments cannot be ignored.

AND WHEREAS, it is equally important that fine particles which constitute higher fractions of toxics are mostly released at ground level sources such as Hotels/Restaurants and Open Eateries/Dhabas/Bakeries, etc. thus further deteriorating the air quality.

NOW THEREFORE, in view of the above, the following directions are issued for necessary compliance:

1. In order to reduce Particulate Matter (PM) as well as odour and in order to improve the air quality, you shall promote using cleaner fuel (i.e. LPG/Electricity) instead of coal or wood fired by Hotels/Restaurants and Open Eateries/Dhabas/Bakeries falling in your jurisdiction.
2. You shall ensure that Hotels/Restaurants and in Open Eateries/Dhabas/Bakeries falling in your jurisdiction are using Liquified Natural Gas (LPG)/ Electric Ovens.
3. You shall ensure that Hotels/Restaurants and in Open Eateries/Dhabas/Bakeries falling in your jurisdiction are using electric instead of coal-based tandoors.
4. You shall ensure that it is mandatory to use LPG/Biogas in commercial eateries.
5. You shall introduce schemes for providing subsidized LPG connections as well as providing means of finance to small tea vendors/hawkers using kerosene stoves to reduce emissions from burning of kerosene.
6. You shall create awareness amongst such establishments for switching to cleaner fuels.
7. You shall ensure that fuel used in bakeries/hotels/restaurants/dhabas etc. shall be electricity, gas or smokeless fuel.
8. You shall ensure that conventional fuels used in the bakeries & tandoors hotels/restaurants/dhabas/open eateries shall be replaced with cleaner fuels in a phased manner in the next one year.
9. The financial assistance to implement the fuel shift may be provided from the funds released under NCAP & Fifteenth Finance Commission (XV-FC) Air Quality Grants to million-plus cities.

The action taken report to be submitted to Maharashtra Pollution Control Board within a period of 30 days from the date of receipt of these directions.

(Dr. Avinash Dhakne, IAS)
Member Secretary

Copy submitted for favour of information:
1) Hon'ble Principal Secretary, Environment & Climate Change Dept., GoM
2) Hon'ble Chairman, MPC Board, Sion, Mumbai - for favour of information

Copy To:
Regional Officers, MPCB - You shall serve copy of direction to concerned ULB and fol[...] for compliance, accordingly.

B

WOOD-BASED CHIMNEY SMOKE OF BAKERY TROUBLING RESIDENTS IN MADANPURA

C

BySabah Virani

Dec 02, 2023 08:06 AM IST

Shahid Shaikh, a resident of Mumbai, has been plagued by toxic smoke from a bakery chimney outside his house. Despite complaints, the BMC has failed to take action, leaving Shaikh to seal up his house at a cost of ₹1.5 lakh. The bakery owner claims switching to cleaner fuel would be expensive. Bakeries in Mumbai have been ordered to shift to cleaner fuels, but many continue to use wood and charcoal, contributing to air pollution. The BMC has promised to send a flying squad to the bakery to issue notices.

Mumbai: After a heart attack last year, Shahid Shaikh has had to be hospitalised five times. After his latest hospital admission on October15, he had to come home to a recurring problem right outside his window in Madanpura, Byculla.

Mumbai,India - Dec. 1, 2023: Madanpura resident Shahid Shaikh filed a complaint with BMC against Central Bakery in Mumbai, India, on Friday, December 1, 2023. (Photo by Raju Shinde/ Hindustan Times)

The chimney of the Central bakery is right outside his house, and it keeps emitting toxic smoke, says Shaikh. "The heat and the smoke were affecting me to such an extent that I had no choice but to go theextra mile and seal up my house."

Shaikh installed an AC and added a glass seal to his window. Helped by his family who added in a coat of paint, this cost them ₹1.5 lakh.

Shaikh has been complaining about the chimney's smoke since 2015 after he lost both his grandmother and his father. He suspects both deaths were hastened by the chimney's smoke. His grandmother died in 2017 due to repeated congestion and infection in her lungs, and, worried that the pollution from the smoke was contributing to it, he hadher shifted to a relative's house in Mumbra. His father suffered from heart problems, diabetes and TB and passed away in 2017.

In response to his complaints, the BMC has always deferred the blame to different departments. The health department asked him to approach the building and factories department as it is the chimney that is illegal. The departments have assured him that action will eventually be taken against the bakery, even issuing a notice under the Section 351 of the MMC Act against the chimney in 2016. HT saw a copy of the show cause notice stating the chimney constructed was illegal. But no action has materialized yet. Shaikh even filed a petitionin the High Court against the bakery in 2018, but the case is still pending.

"All I'm asking is that the bakery shift to using electric or gas as fuel," said Shaikh. Aam Aadmi Party (AAP) leader Aslam Merchant said, "After the resident reached out to me, I have also been complaining onthe BMC's 1916 helpline, but it has made no difference."

The owner of the Central Bakery, Sajid Khurshed Ali, said switching to a different source of fuel would be expensive, "Switching to an alternative source of fuel will cost me at least ₹25 lakh, and I cater to a population of labourers who subsist on cheap pav." He also claimed that his bakery is not the only cause of pollution in the area and that there are other restaurants who also use wood ovens. He also said that he was the landlord of the building in which Shahid Shaikh lives, and as they had filed a complaint and eviction case against him in a civil court, this was a tactic being used against him.

A previous study by National Environment Engineering Research Institute (NEERI) in 2019 quantified the issue, finding that bakeries that use wood and charcoal are responsible for 16% of PM10 emissions.

As per the BMC's air pollution mitigation plan released in March 2023, bakeries were ordered to shift to cleaner fuels from coal or wood, like electric or gas ovens. A senior official from the BMC's E ward said that considering the state of air pollution in the city, using wood as a fuel in bakeries was not allowed. He assured that the flying squad would be informed of the bakery, and they would visit it on Saturday, issuing notices as needed.

In previous cases of complaints too, reported by HT, bakeries have been directed to shift to cleaner fuel or an eco-friendly oven and install scrubbers that will absorb excess dust and carbon emissions.

Figure 11: A: Times of India, October 29, 2023; B: MPCB Directive, February 5, 2024; C: Hindustan Times, December 2, 2023

CHAPTER 3: OPERATIONAL CLASSIFICATION, EFFICIENCY OF BAKERIES AND EXAMPLES

This chapter delves into the classification of bakeries based on various operational parameters, the general process of baking, and the efficiency of different baking methods. It also presents key insights from focused studies on the bakery sectors in Tier 2 cities, specifically Ludhiana, Ghaziabad, and Allahabad, highlighting the challenges and potential energy-saving measures within these regions.

3.1 BAKERIES CLASSIFICATION

Bakeries are classified based on the following parameters as discussed below

- **Stack Height:**

Low-Stack Bakeries: These are bakeries with shorter exhaust stacks. They typically have limited production capacity and may operate in urban areas with height restrictions. Low-stack bakeries are commonly found in densely populated regions. (Approx. 50 ft >)

High-Stack Bakeries: Bakeries with taller exhaust stacks fall into this category. They are often situated in less populated areas or industrial zones. High-stack bakeries are known for their larger production capacity and efficient emission control. (Approx 50 ft<)

- **Oven Type:**

Wood-fired ovens**:** Wood-fired bakeries utilise wood fuel, infusing baked goods with a smoky flavor from combustion by-products. While requiring temperature management expertise and offering a traditional baking experience, they pose environmental concerns due to significant emission levels.

Electric Ovens: Bakeries using electric ovens are known for their precise temperature control and even baking. They are environmentally friendly, as they don't emit pollutants during baking.

Gas-Fired Ovens: These bakeries utilise gas-fired ovens, offering quick heating and cost-efficiency. However, they require proper ventilation and emission control measures.

Hybrid Ovens: Using both firewood and Gas (LPG, PNG, others)

- **Fuel Type:**

Wood-Fired Bakeries: Using firewood/ scrap wood as fuel.

Gas-Powered Bakeries: Bakeries that utilise LPG, PNG, or other natural gas as fuel.

Electricity: Bakeries that utilise Electricity in the process of baking.

Hybrid Fuel: Using both firewood and Gas (LPG, PNG, others), Wood and Electricity or a different combination.

- **Authorization Status:**

Licensed Bakeries: These bakeries that have obtained all the necessary permits and licenses to operate legally. They comply with local health and safety regulations, ensuring product quality and consumer safety.

Unlicensed/Informal Bakeries: These bakeries operate without proper authorization, often in informal or unregulated settings and may pose potential health and safety risks and might not meet quality standards.

3.2 GENERAL PROCESS OF BAKING

The general process of baking as explained in Figure 12 involves several key steps. It begins with ingredient procurement and preparation, followed by mixing and dough preparation. Next is fermentation and proofing, which leads to the baking stage. After baking, the products undergo cooling and inspection. Decoration and finishing are the next steps, ensuring the products are visually appealing. Finally, packaging and quality control are conducted before the products are stored and distributed. This sequence ensures a structured approach to baking, from raw ingredients to finished goods ready for consumption.

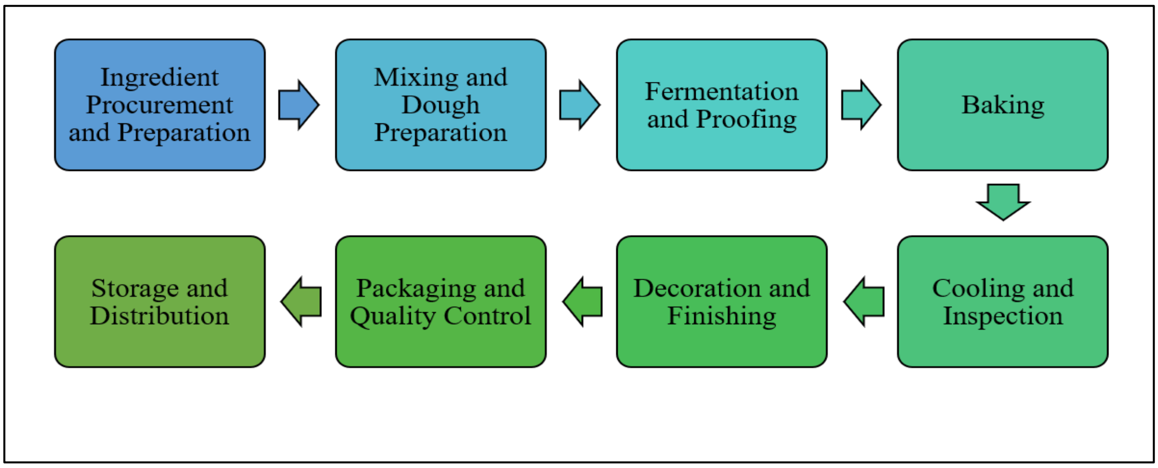


Figure 12: Baking Process

3.3 BAKING METHODS AND EFFICIENCY

Wood-fired ovens, a traditional baking method and is an energy-intensive practice. The actual fuel consumption in such ovens is a complex interplay of factors including the type of flour and bread, the expertise of the baker, oven specifications, wood type, and moisture content. While wood-fired ovens offer unique benefits such as heat control and versatility, they also pose challenges in terms of fuel consumption and environmental impact (13). In recent years, technological advancements have introduced modern alternatives like electric and gas-fired ovens, promising efficiency and environmental friendliness. Yet, the adoption of these alternatives has been slow, influenced by factors such as fuel availability, cost-effectiveness, labour requirements, and consumer preferences (14).

Several studies have delved into enhancing the efficiency of existing bakery ovens, proposing strategies ranging from batch size expansion to fuel combustion improvements (13).

Others have examined the performance of wood-fired ovens and explored ways to optimize their efficiency (15). Additionally, research has been conducted on modifying ovens to accommodate multiple fuel sources, conducting energy audits, and devising mathematical models to understand thermal behaviour (16, 17, 18, 19).

3.4 PROCESS OF BAKING

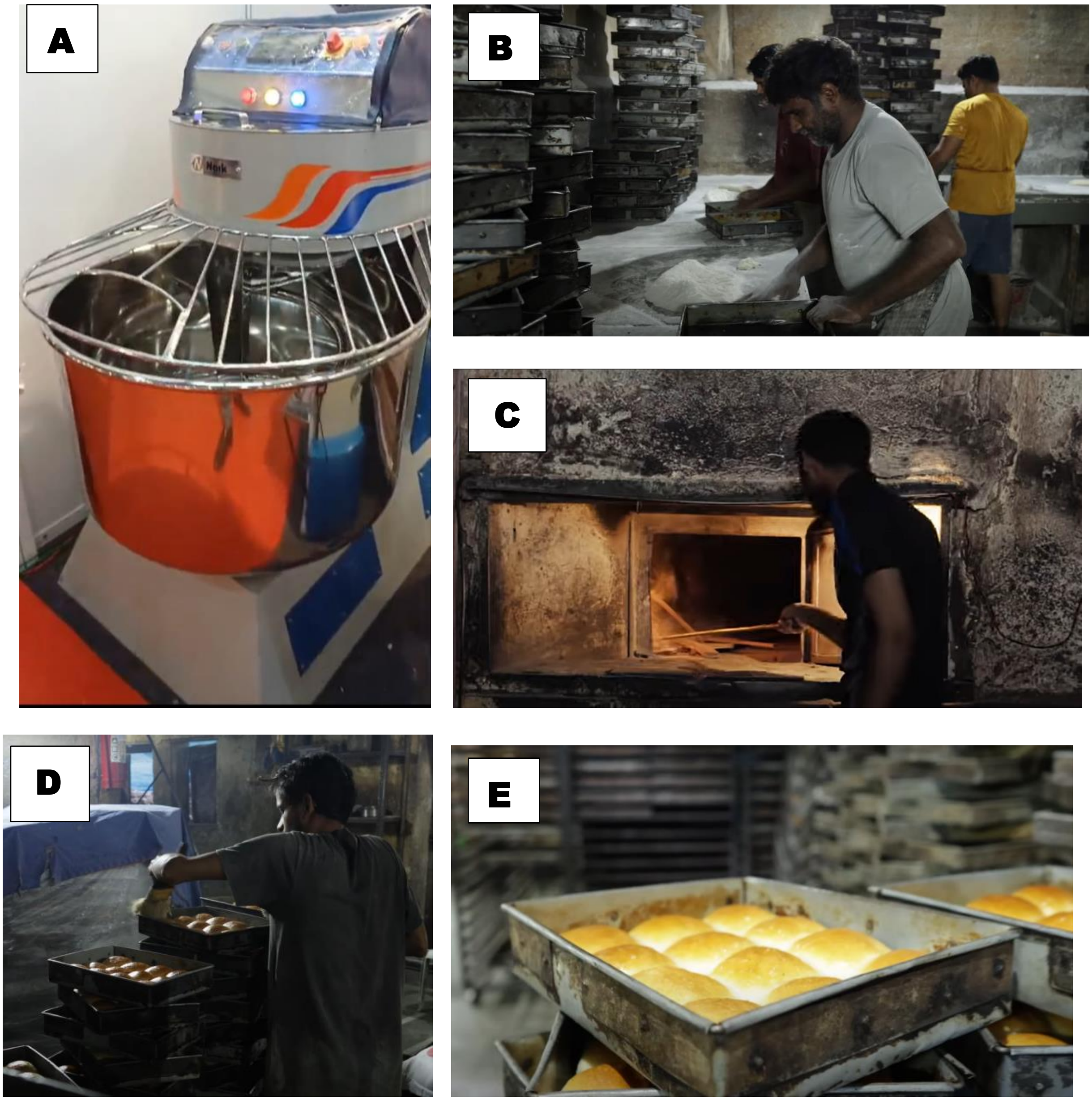


Figure 13: A: Mixing; B: Preparation of Dough; C: Baking; D: Polishing; E: Final product (Pav)

3.5 Key Insights from projects focused on the bakery sector of Tier 2 cities

Ludhiana: Ludhiana, Punjab, has around 39,000 industries, including approximately 200 bakeries and soya processing units within the MSME sector.

- In the bakery sector in Ludhiana High energy consumption due to the use of diesel-fired ovens leads to high operational costs and environmental concerns from carbon emissions.
- Potential energy-saving measures include adopting efficient burners and improved insulation techniques to enhance energy efficiency and reduce costs.
- Collaboration among local bakery owners, government bodies, and research institutions is essential to drive sustainable growth and implement energy-efficient practices.
- Limited cluster development activities in Ludhiana highlight the need for strategic interventions and support mechanisms to promote energy-efficient technologies (20).

Ghaziabad: Bakeries in Ghaziabad face challenges such as rising ingredient costs, labor shortages, intense competition, seasonal demand fluctuations, quality control issues, food safety compliance, equipment maintenance, and supply chain complexities.

- Recommendations include conducting cost analyses, implementing effective pricing strategies, investing in workforce development, and conducting market research to understand and meet consumer preferences.
- Suggests optimizing production and inventory levels during peak and off-peak seasons.
- Identifies the need for further research and improvement in food safety regulations compliance and hygiene standards.
- Encourages collaboration with suppliers, embracing sustainable practices, engaging customers through community events, and leveraging technology for better brand visibility and competitiveness (21).

Allahabad: The bakery cluster in Allahabad comprises about 130 bakeries with a total turnover of Rs 52 crore, focusing mainly on biscuits and pastries (60%) and other products like buns, bread, rusk, and cake (40%).

- Wood is the primary fuel in baking furnaces, with diesel used in rotary ovens and DG sets. Energy consumption accounts for about 25% of production costs.
- Identifies energy-saving measures like energy-efficient burners, insulation for ovens, thyristor control for electrical ovens, biomass gasification in wood-based ovens, direct coupled mixers, reducing baking rack deadweight, switching to rotary ovens, using cogged v-belts, and utilizing solar energy.
- Highlights the potential for energy savings and the need for adopting energy-efficient technologies to enhance the overall efficiency and competitiveness of the bakery sector., natural ventilation, and product branding (22).

CHAPTER 4: OBJECTIVES AND METHODOLOGY

This chapter outlines the objectives, activities, timeline, and methodology of the project aimed at assessing and facilitating the transition of Mumbai's bakery sector from traditional wood-fired ovens to cleaner energy sources. It details the process of data collection, survey design, and analysis to quantify fuel usage, map bakery locations, and identify barriers to adopting sustainable practices. The chapter also discusses the extensive field survey and data compilation efforts to provide a comprehensive understanding of the current state of the bakery industry and propose viable solutions for promoting environmentally friendly baking practices in Mumbai.

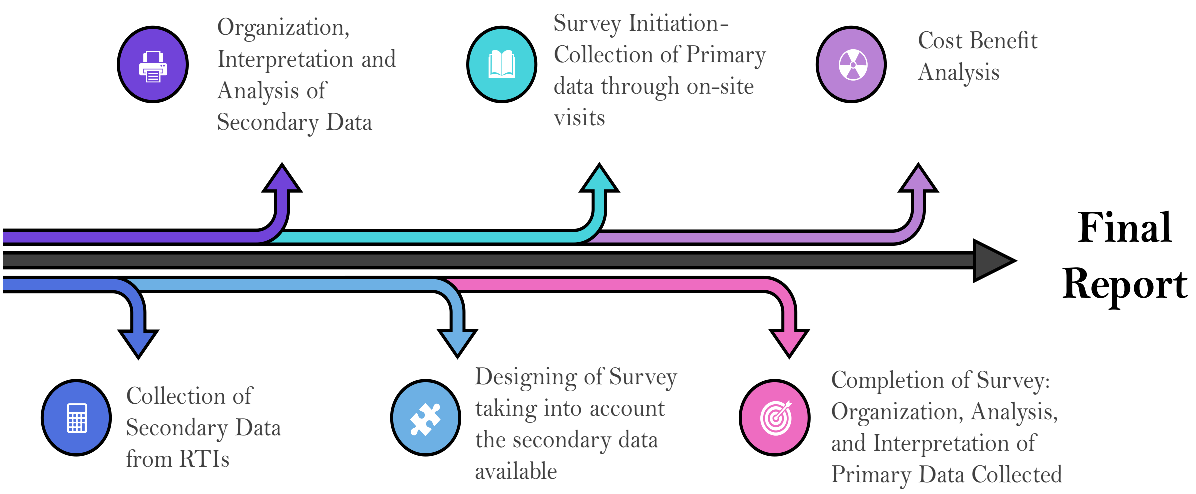
4.1. STUDY OBJECTIVES

As already stated, this project seeks to appraise the possible green transition of the bakery sector in Mumbai. As such, the objectives of project implementation are as follows:

- Report of the survey at different sources to quantify the type & Quality of wood used for bakeries including supply chain, e.g. quantity of flour required, supply areas, quantum of supply, typologies, storages etc.
- Delineation of fuel consumption patterns of bakeries in Mumbai.
- Mapping of the spatial distribution of bakeries within the city.
- Identification of barriers to adopting cleaner fuels.
- Uncovering of reasons for preferring carbon-intensive alternatives.
- Cost Benefit Analysis of the different types of preferred fuels.
- Proposing viable solutions to address the identified issues and promoting sustainable fuel practices among bakeries in Mumbai.

4.2. PROJECT ACTIVITY FLOW

The flowchart outlines the comprehensive steps involved in generating the final report, from data collection and survey design to analysis and cost evaluation, ensuring thorough and systematic reporting.



4.3. PROJECT PERIOD

August 2023 to April 2024

4.4. STUDY METHODOLOGY

The project is divided into 3 phases:

Phase 1: Data Collection and organization from secondary sources

Data regarding registered bakeries in Mumbai was gathered through the Right to Information (RTI) process for the years 2017, and 2023, Bombay Bakers Association (BBA), and Indian Bakers Association. The Bombay Environmental Action Group Bombay Environment Action Group (BEAG) facilitated the RTI requests by submitting applications at each ward office to obtain information on all bakeries within each ward. Standard RTI protocols were followed, including drafting formal applications addressed to the designated Public Information Officer (PIO) of the relevant government department or organization. These applications included the applicant's details, a clear description of the information requested, and the preferred mode of access. Upon application and payment of fees, the requested information was obtained within the stipulated timeframe. The data, received in PDF formats via email, was then segregated and analysed. Additionally, attempts were also made to obtain some information related to GST filings of bakeries to get another line of information to enhance our understanding from the GST Commissioner of Maharashtra, but these efforts weren't fruitful.

Phase 2: Data Compilation and Initiation of Survey

In this phase, the focus was on Data Compilation and Survey

Between August and September 2023, a team of three individuals compiled data from the RTIs obtained for 2017 and 2023, as well as from the Bombay Bakers Association and Indian Bakers Association, into separate Excel sheets. This data compilation was undertaken to create a dataset for further sampling and survey investigations regarding fuel choices among bakeries. Additionally, an existing Excel dataset was provided containing information on all wards, their respective bakeries, addresses, and some fuel type details along with contact information. However, not all mentioned information was available, and data gaps were identified. Some bakeries lacked proper addresses, names, or contact information, while information for certain wards was missing entirely from the RTIs. Specifically, the RTI for 2023 did not provide data for M/E, G/N, and R/C wards, while the RTI for 2017 lacked data for H/W and K/W wards. Furthermore, there were instances in some wards where bakery names were missing or addresses were incomplete within the obtained RTI reports.

Concurrently, the process of mapping these bakeries commenced utilizing Google Earth, Google Maps, and ArcGIS software. Separate maps were created for the data obtained from RTI 2017 and RTI 2023, followed by a combined map. Initially, addresses were pinpointed on Google Earth; however, due to missing information such as bakery names and incomplete addresses, locating some bakeries proved challenging. In such cases, nearby locations on the map were selected as substitutes for bakery locations. Upon completing the ward-wise mapping of bakeries, it was noted that a few addresses did not correspond to the same ward but were registered within that ward. All locations identified using Google Earth were exported as KML files for further map processing.

The KML files were converted to coordinates using GPS Visualizer, and the resulting coordinates were transferred into Excel sheets for further use in plotting with ArcGIS. Before plotting, a base map was prepared in ArcGIS, ensuring it shares the same coordinate system as the coordinates obtained. Following base map preparation, the plotted points were overlaid onto the map, and the map was exported. In ArcGIS, additional layers can be incorporated to enhance the visual representation as needed.

Following the completion of map creation and data compilation, the next phase involved conducting a field survey. A questionnaire (Annexure 1) was prepared before initiating the survey. This questionnaire was structured to facilitate conversation flow with bakery owners, with questions designed to guide discussions. To initiate dialogue, it was decided to purchase products from the bakeries, serving as an icebreaker and directing conversations towards obtaining desired information. The questionnaire covered topics such as product types, raw material and fuel requirements, fuel sources, procurement, fuel cost, and availability. To test the methodology, a pilot study was conducted at a bakery in Dadar without a copy of the questionnaire, aiming to gauge whether bakery owners or workers would engage in conversation and provide the desired information. Surveys were conducted in two phases: from September to November and from December to February. In the first phase, a team surveyed A, B, C, D, E, F/S, F/N, G/S, S, and T wards in southern and eastern Mumbai. In the second phase, teams covered L, H/E, H/W, R/S, K/W, P/S, and M/W wards in central and northern Mumbai.

ESTABLISHMENT OF SAMPLE SIZE

Upon organizing and compiling data obtained from the RTIs, it was noted that according to RTI 2017, there were a total of 528 bakeries across all wards, while RTI 2023 reported 527 bakeries. However, both RTIs lacked information for certain wards. Consequently, RTI 2023 was chosen to design the survey due to its more recent data. Missing ward information from RTI 2023 was supplemented with data from the provided Excel sheet, resulting in a total of 628 bakeries considered across all wards. Online tools were utilised to establish a sample size for the survey to ensure a **90 percent confidence level** in the obtained responses. It was decided that bakeries failing to provide any information would be treated as null. After revisions, a final sample size of 200 was established, using a **random sampling method**. Efforts were made to ensure a significant representation of bakeries from all wards to avoid biased results.

PHASE 3: Data Analysis

In Phase 3 of the project, the focus was on data analysis and interpretation. The initial step involved categorizing data based on ward-wise and zone-wise distribution using the 2017 and 2023 RTI data. Additionally, it was conducted with a comprehensive cost-benefit analysis of the various fuels utilised within the bakery industry. The analysis also delved into the presence of volatile organic compounds and the resultant health impacts on bakery workers, with a specific emphasis on those employed in wood-fired bakeries. Furthermore, it aimed to identify key factors that could potentially impede the transition to cleaner fuels within the bakery sector.

CHAPTER 5: OBSERVATIONS AND DISCUSSION

This chapter presents the results of Phase 1 and Phase 2 of the project. Phase 1 covers the data collection, organization, and analysis of the number of bakeries and its distribution across each ward, while Phase 2 encompasses the survey process, its findings, inferences, cost-benefit analysis, and identified gaps.

RESULTS

5.1. FINDINGS OF PHASE 1

Evaluating the spatial distribution (both ward-wise and zone-wise) of bakeries in 2023 vis-à-vis 2017 reveals several changes.

5.1.1. WARDWISE DISTRIBUTION OF BAKERIES

The ward-wise distribution of bakeries as shown in Figure 14 indicates the number of bakeries in each ward as obtained from RTI 2017 and RTI 2023. A comparative graph shows whether the number of bakeries in each ward has increased, decreased, or not changed.

Table 3 depicts the direction of change in the number of bakeries across each ward while comparing RTI 2017 & 2023.

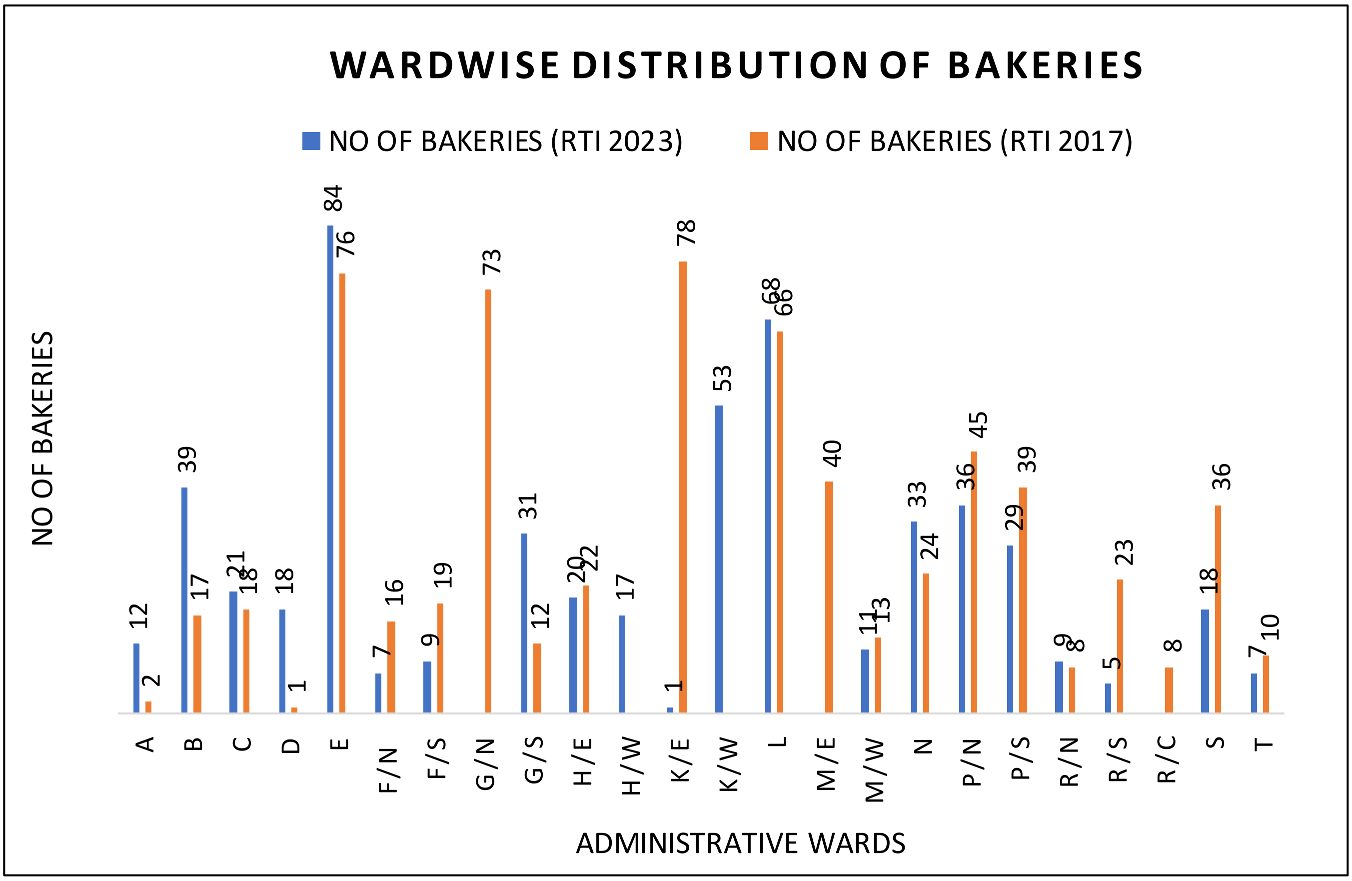


Figure 14: Ward-wise distribution of bakeries

Table 3: Variation in the number of bakeries

WARD	CHANGE IN THE NUMBER OF BAKERIES IN 2023 VIS-À-VIS 2017	DIRECTION OF CHANGE
A	10	Increase
B	22	Increase
C	3	Increase
D	17	Increase
E	8	Increase
F/N	11	Decrease
F/S	10	Decrease
G/N	**NA (unavailability of data in RTI)**	NA
G/S	19	Decrease
H/E	2	Decrease
H/W	**NA (unavailability of data in RTI)**	NA
K/E	77	Decrease
K/W	**NA (unavailability of data in RTI)**	NA
L	2	Increase
M/E	**NA (unavailability of data in RTI)**	NA
M/W	2	Decrease
N	9	Increase
P/N	9	Decrease
P/S	10	Decrease
R/N	1	Increase
R/S	18	Decrease
R/C	**NA (unavailability of data in RTI)**	NA
S	18	Decrease
T	3	Decrease

* *For wards and corresponding areas refer to Annexure IV*

5.1.2. ZONEWISE DISTRIBUTION OF BAKERIES

The city has been divided into seven distinct zones, each designated with its own unique set of wards. Zone 1 encompasses wards A through E, while Zone 2 consists of wards F/S, F/N, G/S, and G/N. Zone 3 comprises wards H/E, H/W, and K/E, while Zone 4 includes wards K/W, P/S, and P/N. Zone 5 encompasses wards L, M/E, and M/W, and Zone 6 includes wards N, S, and T. Finally, Zone 7 is made up of wards R/S, R/C, and R/N. This zoning system serves to efficiently organise and manage the various regions of the city, ensuring effective governance and provision of services to residents across all areas. The distribution of bakeries in each zone and the direction of change are shown in Figure 15 and Table 4 respectively.

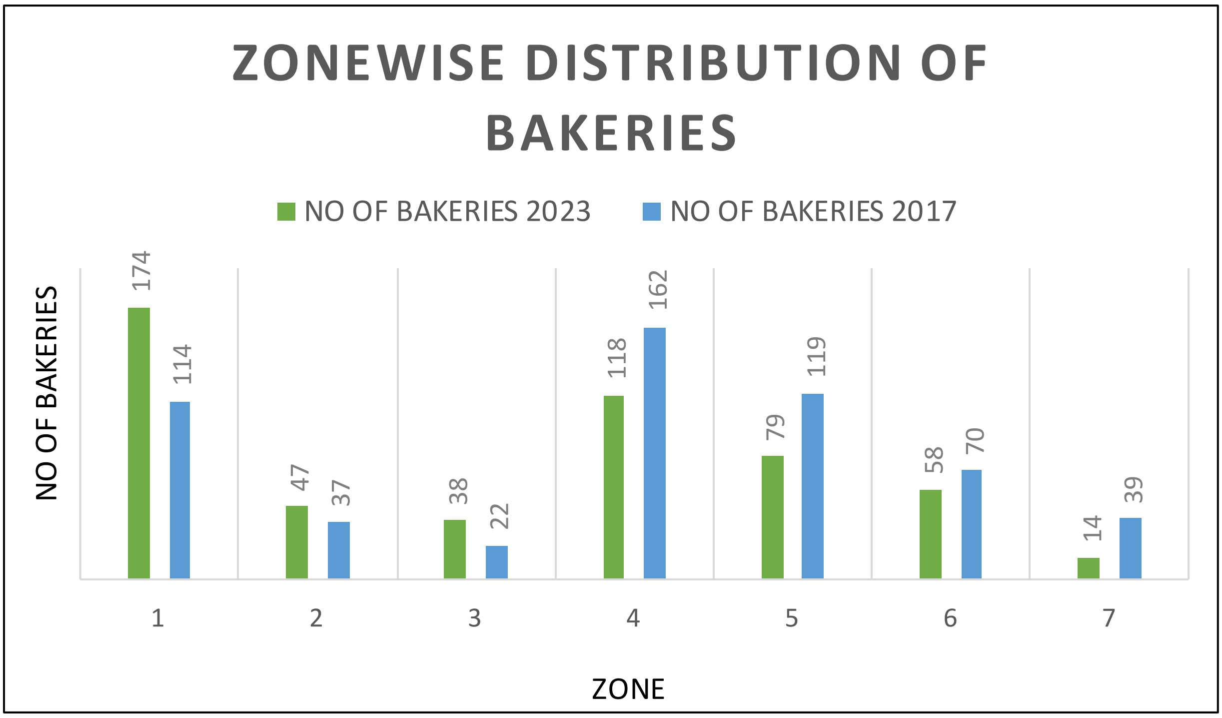


Figure 15: Zone-wise distribution of bakeries

Table 4: Zone-wise distribution of bakeries

Zone No.	Wards	Change in the number of bakeries in 2023 vis-à-vis 2017	Direction of change
1	A, B, C, D, E	60	Increase
2	F/S, F/N, G/S, G/N	10	Increase
3	H/E, H/W, K/E	16	Increase
4	K/W, P/S, P/N	44	Decrease
5	L, M/E, M/W	40	Decrease
6	N, S, T	12	Decrease
7	R/S, R/C, R/N	25	Decrease

5.1.3. OUTCOMES OF THE MAPPING PROCESS

The mapping process conducted using **ArcGIS** and **Google Earth Pro** facilitates the comparison of bakeries in the year 2023 vis-à-vis 2017 by providing visual inputs describing the change in the number of bakeries over time. It must be reiterated that the mapping process was conducted using the sampling frame created by synthesising the information contained in RTI data, particularly of 2023 along with filling the gaps using RTI data of 2017. This process contributed significantly in making the administration of the survey a seamless process by providing geographical information of sampling units. It also reduced significantly the costs associated with doing such a survey.

Figure 16 depicts a map that highlights the shifts in the spatial distribution of the bakeries between 2017 and 2023. This map is the visual/graphical counterpart of the numerical analysis presented in the preceding subsection.

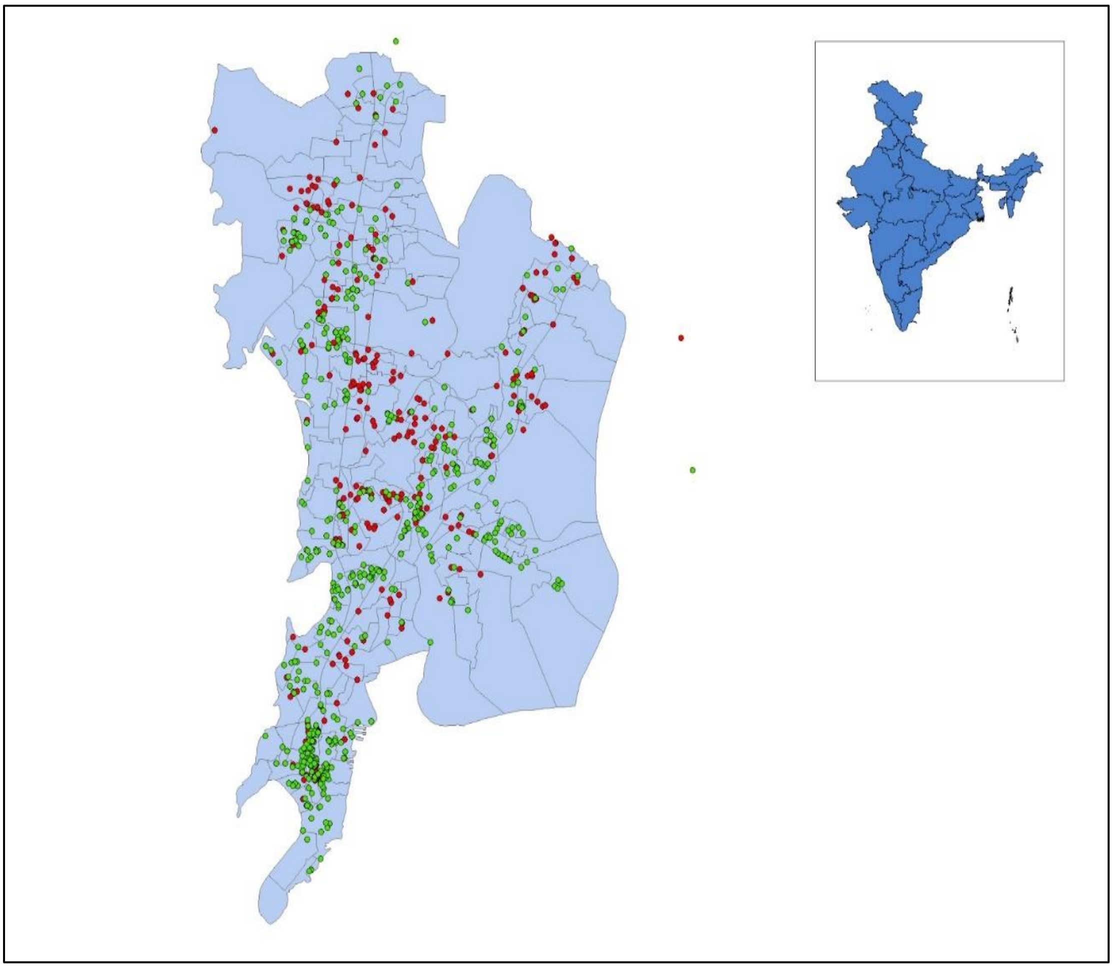


Figure 16: Spatial distribution of bakeries as per RTI 2017(Red) and RTI 2023(Green)

A map of Mumbai showing different wards along with the location of bakeries (green dots) as per data obtained from RTI 2023 is indicated in Figure 17.

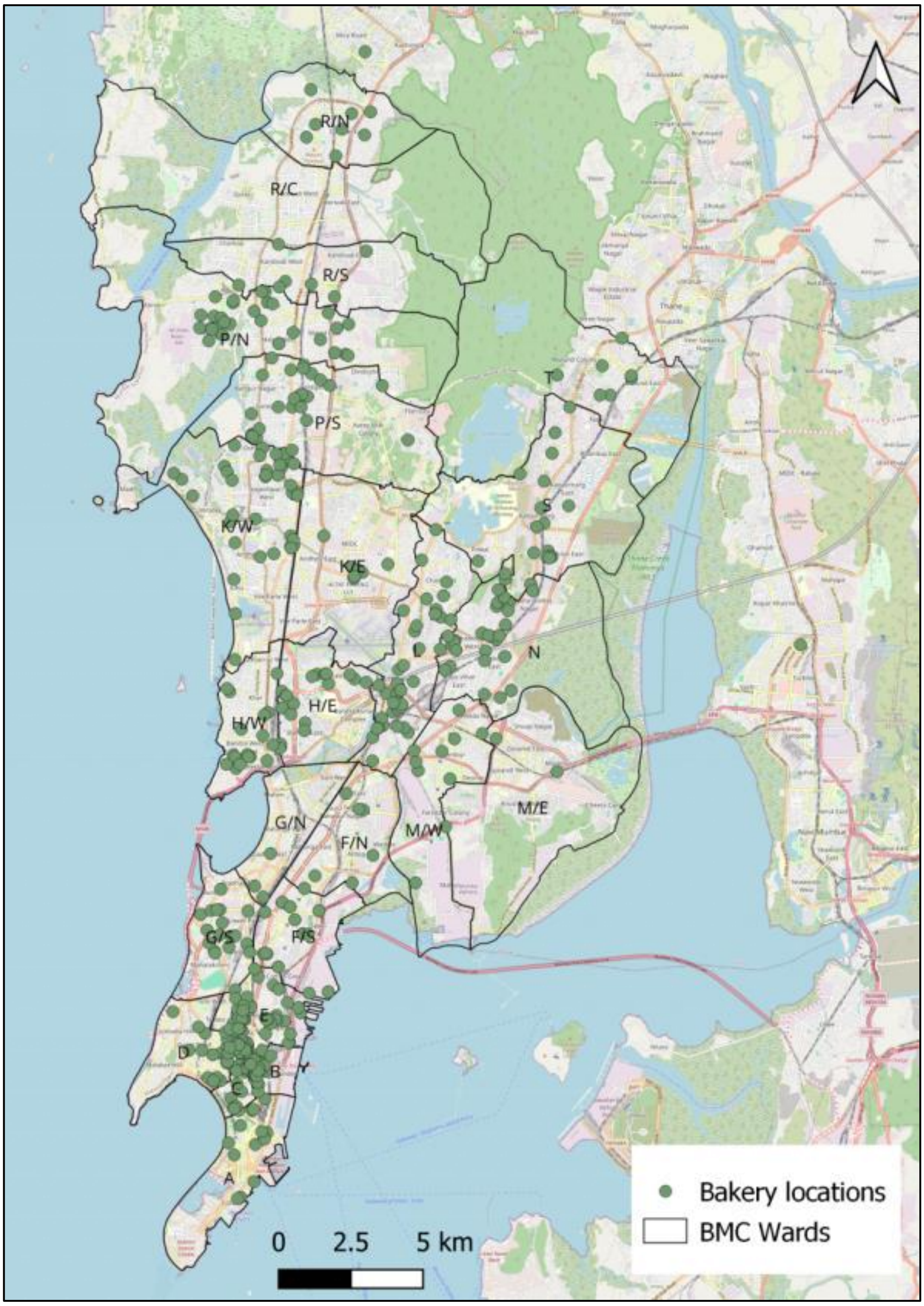


Figure 17: Location of bakeries in each ward according to RTI 2023

It follows from the gradient map (Figure 18) that only ward H/W has the bakery number greater than 80 and is home to the largest number of bakeries at 87. Most wards (specifically, 10) have number of bakeries in the range of 8-20. Seven wards have number of bakeries between 20 and 40. Wards P/N, K/E, and E have the number of bakeries greater than 40 but less than 60 while the number of bakeries in wards G/N and L exceed 60 but are lower than 80. A significant number of bakeries, both authorized and unauthorized, operate in areas such as Dharavi, Bandra, and Khar. The actual number of bakeries may exceed those officially registered with MCGM (4).

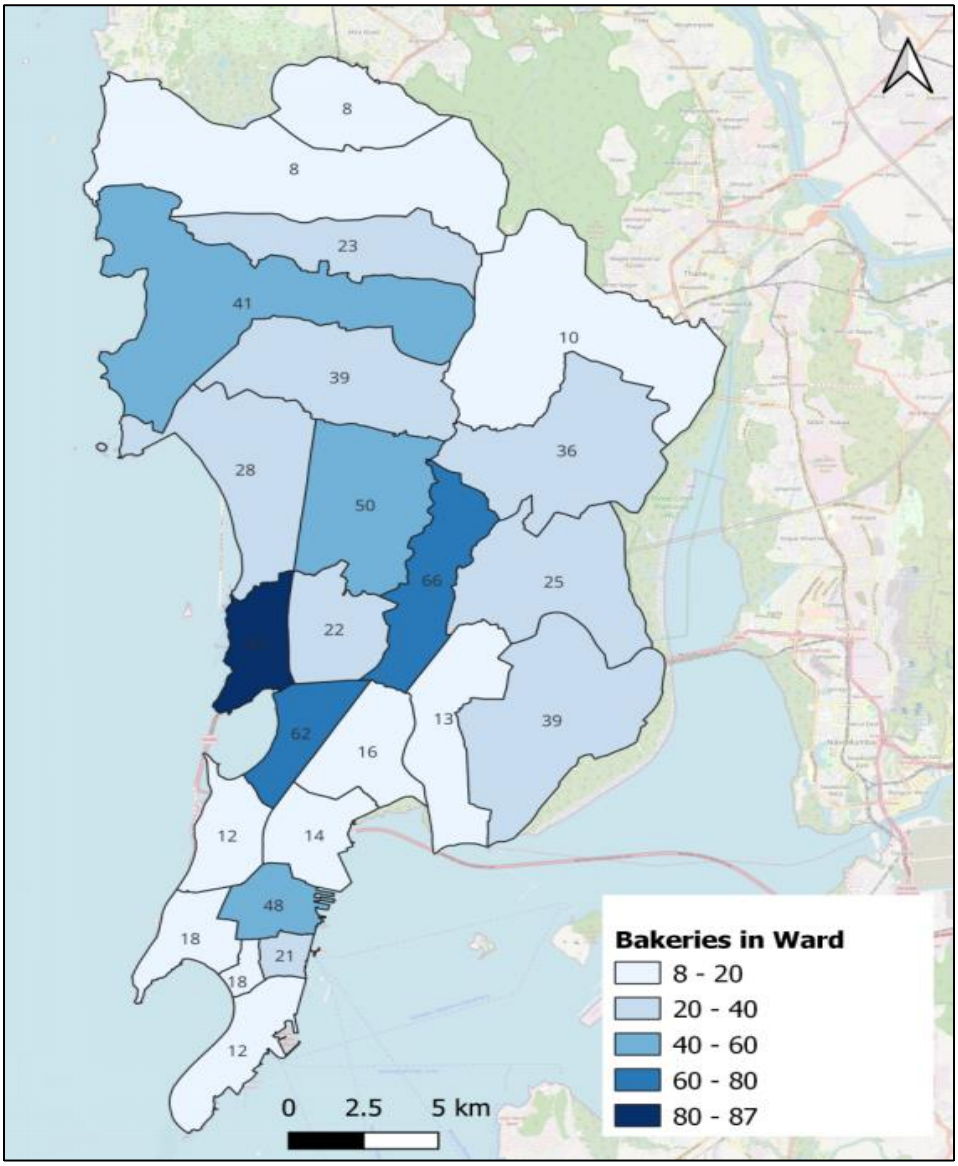


Figure 18: Gradient map depicting the range of number of bakeries in each ward

As many as 19 wards are dominated by wood-fired bakeries, that is, the proportion of wood-fired bakeries in these wards exceeds 50 percent. The proportion of wood-fired bakeries is the largest in Ward E at 98 percent and is the smallest in Ward T as indicated in Figure 19. However, areas with lighter shades indicate affluent residential zones, where electrically operated bakeries are more prevalent than wood-fired bakeries.

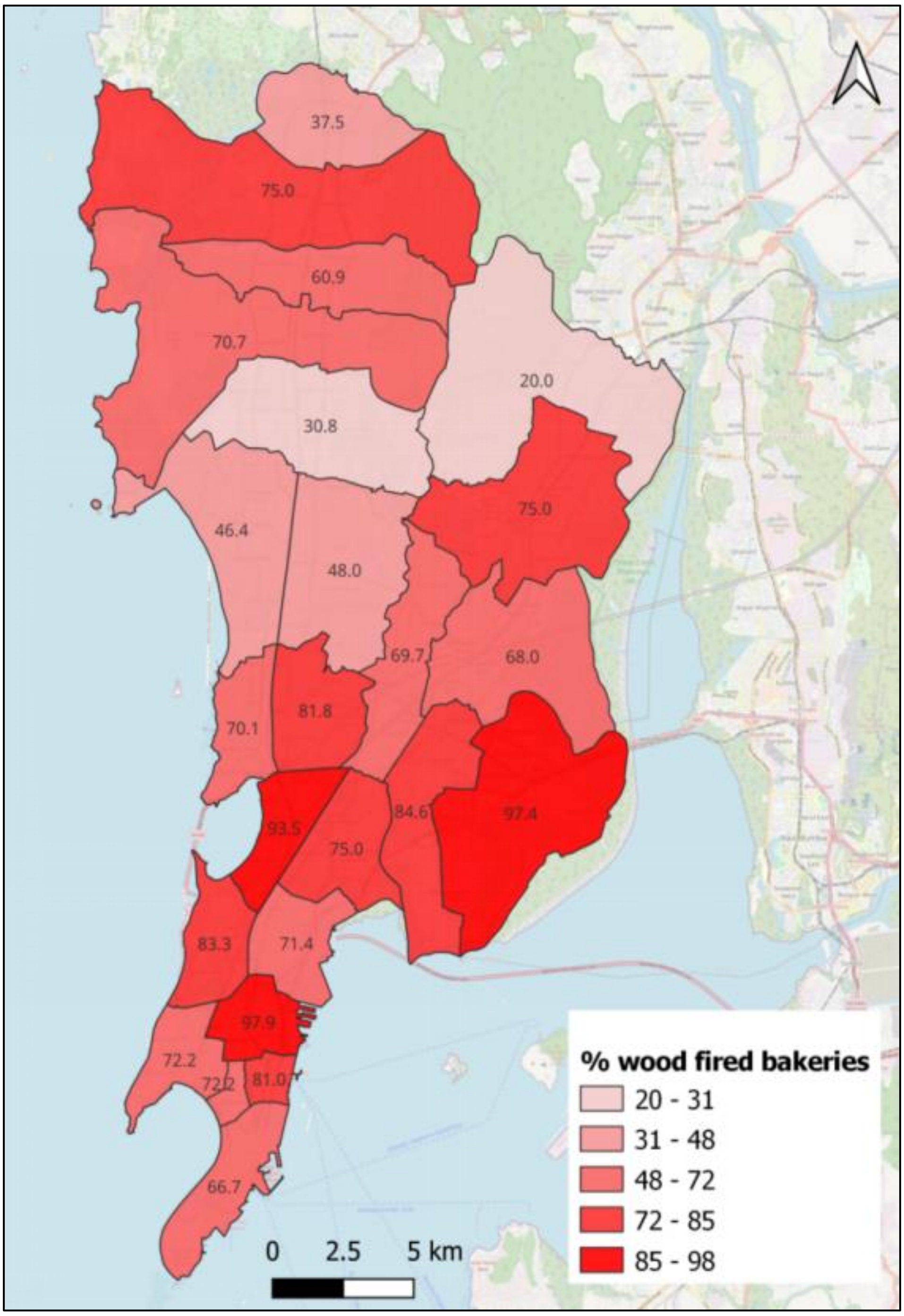


Figure 19: Gradient map depicting the proportion of wood-fired bakeries across wards

Figure 20 A and B show a map relative to slum clusters and a gradient map providing a visual representation of the concentration of bakeries in slum clusters respectively. It indicates a significant overlap between bakeries and slum clusters. The concentration of bakeries in slum clusters is the highest in the case of the L ward. This concentration is prominent in wards K, P/N, and R/N among others. It was also observed that most of the *'pav'* making bakeries were situated near the slum areas and scrap wood markets.

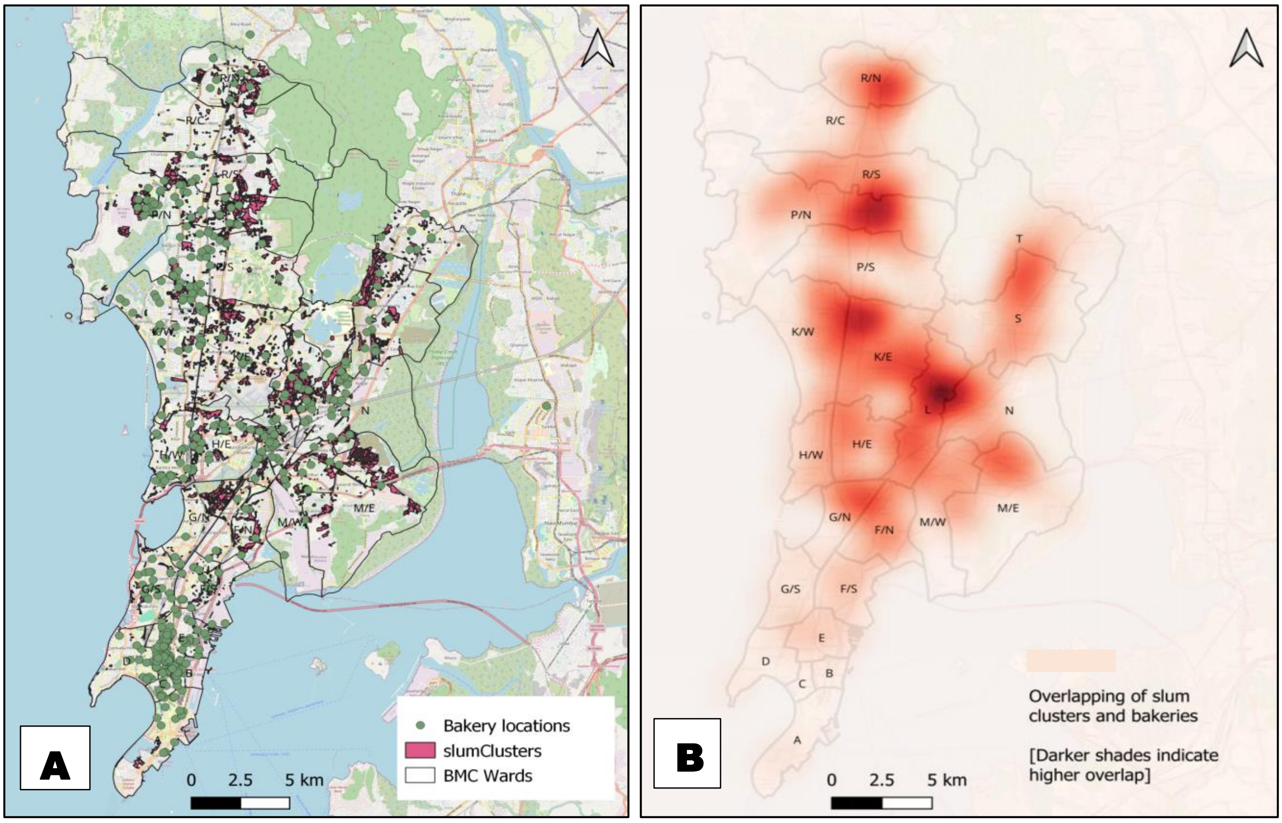


Figure 20: A: Location of bakeries relative to slum clusters; B: Gradient map: overlapping of slum clusters and bakeries

5.2. FINDINGS OF PHASE 2

Following the conclusion of the survey, a thorough analysis of the collected data has uncovered valuable insights into the operations of the surveyed bakeries. These observations illuminate crucial aspects such as operational practices, the types and quantities of fuel utilised, production quantities, and supply areas, as well as brief interactions with oven manufacturers. By delving into these details, key findings have surfaced, offering a comprehensive understanding of the dynamics within the bakery sector. This meticulous examination not only highlights current practices but also provides valuable insights into emerging industry trends.

5.2.1. SURVEY DYNAMICS:

The dynamics of the survey are as follows:

- Table 3 indicates the total number of surveyed bakeries within the sample. It also shows the number of bakeries that responded, partially responded and refused to respond.
- The number of wards surveyed stands at 17, and the total number of bakeries surveyed is 216.
- Quite a few bakeries did not wish to respond or were closed during the survey.
- The addresses of some bakeries were inaccurate.
- In some cases, bakeries function as retail shops despite having the nomenclature of a bakery.

Table 5: Survey Dynamics

PARTICULARS	COUNT
Total no. of wards surveyed	17
Total no. of bakeries visited	216
No. of the bakeries responded	153
No. of unresponsive bakeries	18
Bakeries providing partial data	16
No. of bakeries not located	3
Bakeries permanently closed	26
Retail shops named as bakery	16

5.3. DISTRIBUTION OF BAKERIES ACCORDING TO FUEL CHOICES

Bakeries surveyed across Mumbai were found to be using Wood, LPG, Diesel, Electricity, PNG or a combination of any two as fuel. Among the surveyed bakeries, the details of the fuel choices are as follows (Figure 21):

- Wood was the most commonly used fuel type among surveyed bakeries i.e. 47.10%, with 72 establishments using it.
- Electricity was the second most prevalent energy source contributing 28.10%, with 43 bakeries relying on it.
- LPG (liquefied petroleum gas) was used by 32 bakeries i.e. 20.90%.
- Diesel and PNG (piped natural gas) were the least utilised energy sources, each employed by only 2 bakeries each and occupying 1.30% respectively.
- 2 bakeries utilised a combination of wood and LPG as their energy sources which makes 1.30%.

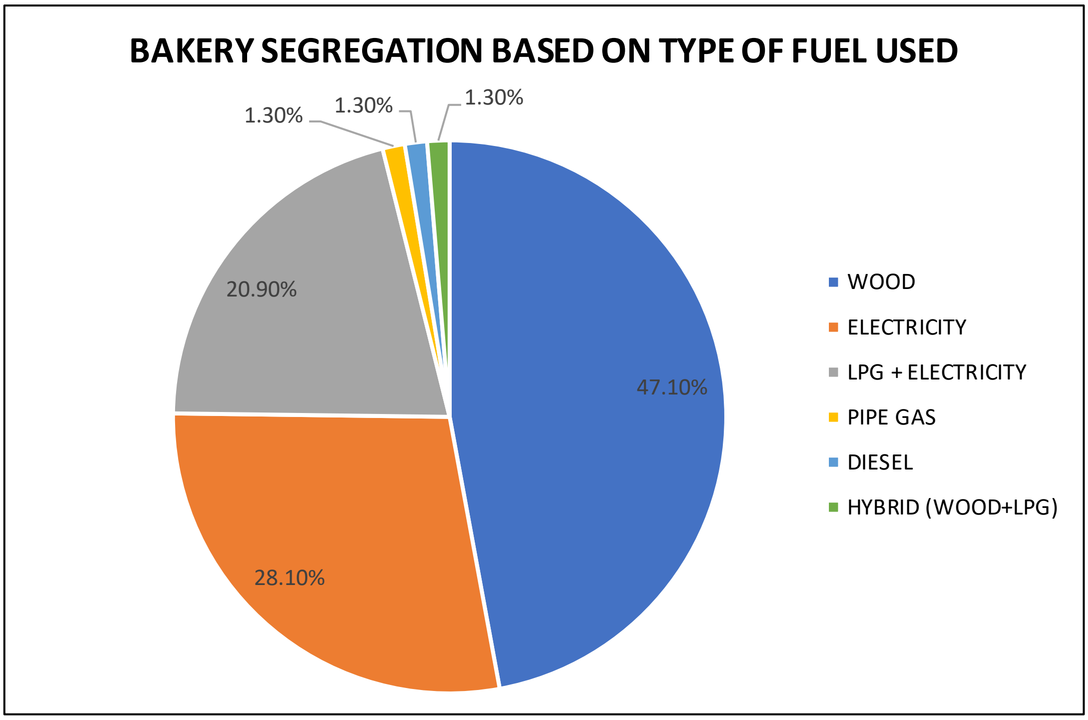


Figure 21: Bakery segregation based on types of fuel used

5.4. WARDWISE STATISTICS OF TYPE OF FUEL USED

Table 6: Surveyed Bakeries across each ward and their fuel type

WARD	TOTAL BAKERIES VISITED	WOOD	ELECTRICITY	LPG	DIESEL	PNG	HYBRID	NO DATA
A	9	2	3	0	0	0	1	3
B	21	7	8	1	0	0	0	5
C	8	2	4	0	0	0	0	1
D	17	6	6	0	0	0	1	4
E	23	12	7	1	0	0	2	1
F/N	8	2	4	0	1	0	0	1
F/S	7	4	0	1	0	0	1	1
G/S	7	1	2	0	1	0	0	3
H/E	15	7	1	2	0	0	1	4
H/W	19	10	2	1	0	0	0	7
K/W	21	2	0	13	0	0	0	6
L	13	5	4	0	0	0	1	3
M/W	8	2	0	3	0	2	0	1
P/S	13	3	0	4	0	0	0	6
R/S	5	2	0	1	0	0	0	2
S	14	7	1	1	0	0	1	4
T	7	1	1	0	0	0	1	4

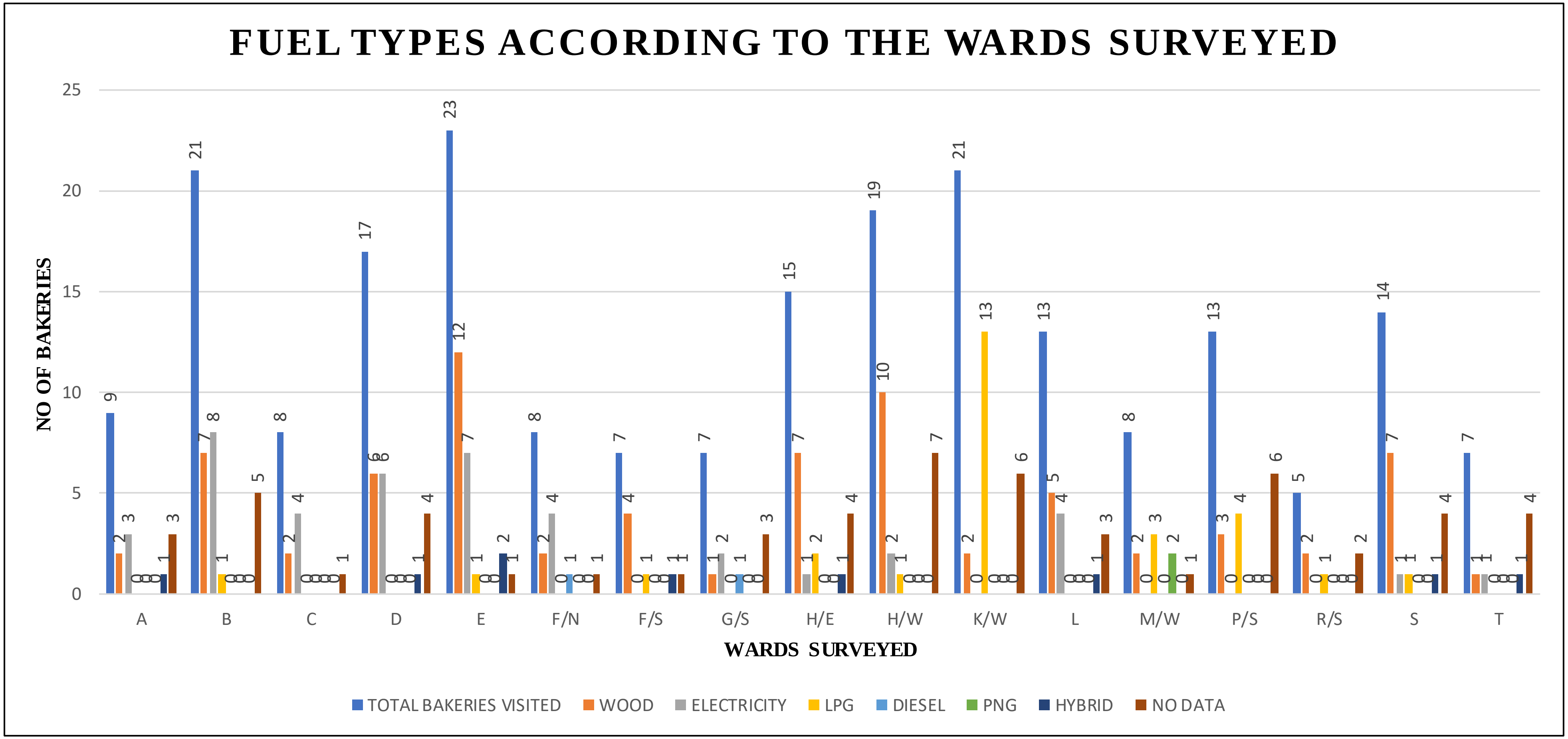


Figure 22: Type of fuel used by the surveyed bakeries across each ward

The summary of fuel used in different wards is as follows: (Figure 22 & Table 6)

- Ward E surveyed the highest number of bakeries with 23 visits, followed closely by wards B and K/W with 21 and 21 visits respectively.
- Wood and electricity were the primary energy sources for most wards, with varying proportions.
- Ward E had the highest usage of wood and electricity, with 12 and 7 bakeries respectively.
- Ward K/W notably relied heavily on LPG for energy, with 13 out of 21 bakeries using it.
- Ward H/W encountered the most instances where data on energy sources were not available or very precisely not shared, with 7 such cases.
- Hybrid energy systems were observed in a few wards, such as wards E and H/E.
- Wards F/N and F/S encountered a similar number of bakeries but differed in their energy sources, with F/N having one bakery using diesel and F/S having one bakery using LPG.
- Ward R/S surveyed the fewest number of bakeries, 5, with 2 of them having no data on energy sources.
- PNG was not a commonly used energy source among the surveyed bakeries.
- Across all wards, a total of 31 bakeries had no data available regarding their energy sources.

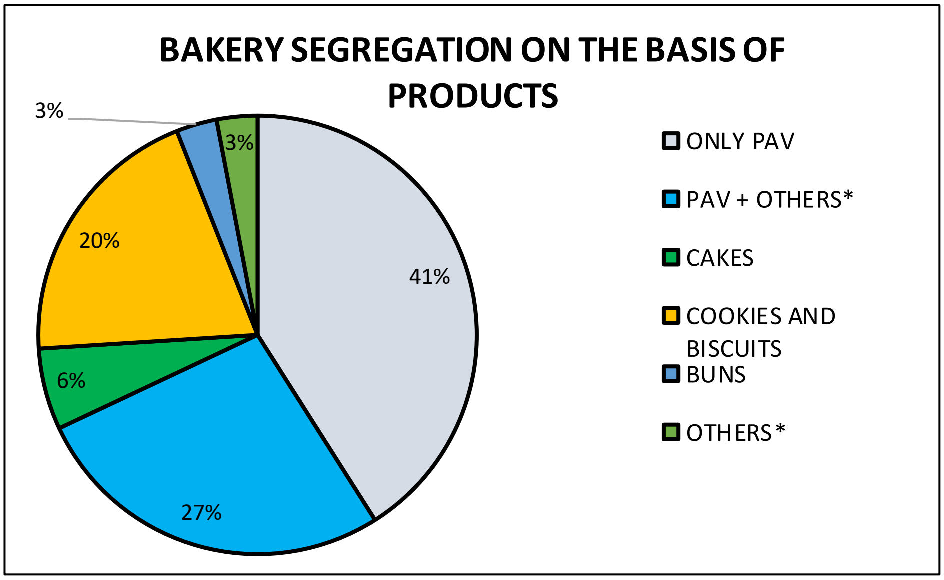
5.5. PATTERNS OF AND REASONS FOR FUEL CHOICES:

The reasons and patterns of fuel choices are:

- Sources of fuel other than wood include electricity, diesel, LPG, gas, and a combination of any of these fuels (referred to as hybrid).
- It is assumed by the bakery operating folks that electricity costs three times more than wood.
- LPG cylinders of 15-19 kgs are used and are expensive as compared to wood but cheaper as compared to electricity.
- Availability of electricity is erratic as compared to wood and LPG which has a reliable supply
- Wood ignites at a faster rate and makes it easy to heat ovens.
- Demand for products baked using wood is higher than those baked using other fuels.
- The production of cake often relies on hybrid fuel.
- Bakeries exhibit diverse fuel usage patterns based on the scale of production and bakery goods being produced.

5.6. PRODUCTION OF BAKERY GOODS

- Bakeries are engaged in the production of bakery goods such as biscuits, cookies, *'Khari,'* toast, butter, and *'Pav.'*
- In terms of manufacturing bakery goods, the number of bakeries producing only '*pav'* is the largest among those surveyed (Figure 23).



Others: - Khari, Toast, Butter, Cakes, etc.*

Figure 23: Segregation based on products

5.7. SCALE OF OPERATION AND EMPLOYMENT STRUCTURE OF BAKERIES

- Small bakeries employ 8-10 workers.
- Large-scale bakeries employ over 25 workers.
- Large bakeries operate 24/7; others have specific hours.
- Large bakeries cater to the demand throughout the city of Mumbai.
- Bakeries which predominantly focus on '*pav*' production serve markets spanning 2-3 nearby local stations.

5.8. WOOD CONSUMPTION BY BAKERIES

The amount of wood utilised by bakeries depends on several factors as discussed with bakery owners. A large amount of wood was found to be used by bakeries involved solely in the production of '*pav*' and those whose operation hours are either very high or 24/7.

The details of wood utilised, its cost, and formed products are as follows:

- The number of bakeries which, on average, consume between 50 and 100 kilograms of wood per day is the largest among those surveyed (Figure 24).
- Average consumption of wood by wood-fired bakeries is about 130kgs per day.
- Large bakeries use 250-300kgs per day.
- About 4-5 kgs. of wood are required for processing 20 kgs. of flour into '*pav*', the most widely produced bakery goods.
- Wood-fired bakeries use scrap wood obtained from nearby markets. These bakeries are often located close to scrap wood markets.
- The preference for scrap wood over logwood could potentially be explained by cost considerations. More specifically, scrap-wood costs INR 4-5 per kg versus log-wood which costs INR 10-12 per kg.

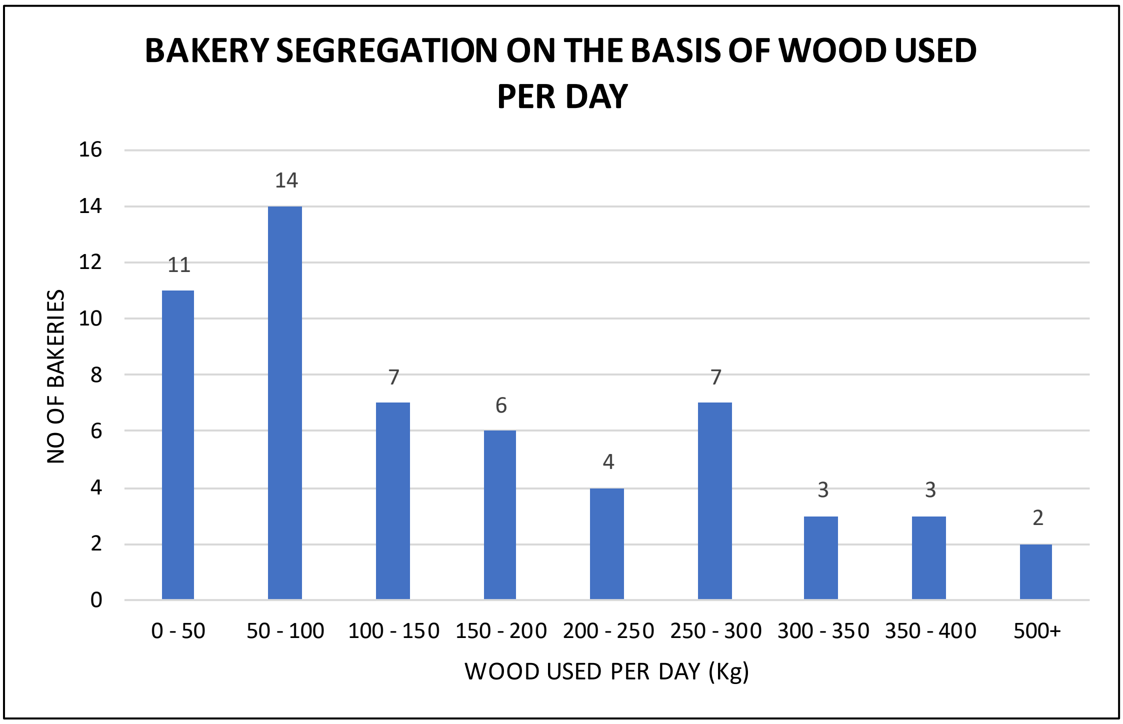


Figure 24: Per day wood usage of bakeries

5.9. WOOD DEPOT VISIT

Several visits were made to wood depots that sell wood for furniture and other long-term use and scrap wood dealers that sell waste wood that includes plywood, broken pieces etc. while some refused to interact, interactions that yielded some information are mentioned below.

5.9.1. REAY ROAD

Multiple wood depot visits were made of which a wood depot at Reay Road near N.N. Bakery readily provided information. It was explained that the wood sourced at the depot comes from regions outside Maharashtra, such as Madhya Pradesh and Karnataka. This wood is primarily used for furniture making due to its high quality. Teak was highlighted as the most expensive wood available, with other varieties including *shisham,* mango, and babul. The leftover scrap wood from furniture production is supplied to nearby bakery units as fuel. Typically, this type of wood is transported in large quantities, measured in tonnes.

5.9.2. INTERACTION WITH SCRAP WOOD DEALERS

The scrap market located in the interiors of Sonapur, Bhandup, was visited, where a large number of bakeries operate using scrap wood. It was informed to the surveying team that this scrap wood is obtained from wood depots, building construction sites, and customers who sell it to them. The wood typically includes wooden frames of windows and doors, broken pieces of wood, and remnants from furniture manufacturing. This wood is sold to the bakeries regularly, with prices ranging from as low as 2 rupees per kg to as high as 6 rupees per kg, and is purchased by the bakeries in tonnes. However, this wood is not cleaned before being provided; it is not free of rusted nails or other metallic articles attached to it, posing potential safety hazards and reducing the efficiency of the burning process.

The use of scrap wood in bakery operations has several negative implications. The presence of rusted nails and other metallic articles in the wood can damage baking equipment and pose safety hazards for workers. Burning such untreated wood, which often contains glue and other chemical residues from construction materials, leads to incomplete combustion. This not only affects the quality of the baked products by imparting unwanted flavours and potential contaminants but also significantly increases harmful emissions. The release of toxic fumes and particulate matter from burning adhesives and wood contributes to air pollution and poses severe health risks to bakery workers and nearby residents. Therefore, while the low cost of scrap wood is economically appealing, its use in baking operations presents serious environmental and health concerns that need to be addressed.

5.10. MANUFACTURER VISITS

Visits to oven manufacturers were arranged to gain insights into the shift of bakeries towards cleaner fuel alternatives. The objective was to gather details about the ovens, including their functionality, operating expenses, benefits, capacity, and other relevant aspects. These visits facilitated our understanding of the obstacles present and potentially emerging in the widespread transition of bakeries, which traditionally use wood as fuel, to cleaner energy sources.

Five oven manufacturers in Mumbai were selected through online searches using Google. The selection was based on factors such as their geographical proximity, operational status as indicated on Google, and the types of ovens they produce. Contact was established with these manufacturers by navigating through their websites and scheduling appointments via phone calls. Visits were arranged during their business hours, with a team of two individuals equipped with a questionnaire (Annexure II) designed to extract relevant information contributing to comprehensive data analysis.

The initial visit was conducted at Naik Oven Manufacturers located in Majhiwada, Thane. This unit was conveniently located and easily identifiable on Google Maps, with accessible public transportation options. While direct interaction with the owner was not possible, a supervisor- guided us through the facility. They showcased various machinery produced by the company, including mixing machines, ovens of different capacities, oven parts, and other equipment. The supervisor provided comprehensive details about the manufacturing process, installation procedures, oven capacities, and operational modes, as well as information regarding fuel types, consumption rates, and associated costs. The specifics of this information are outlined below.

The second visit was arranged to Abcon Oven Manufacturers situated in Govandi. Despite appearing as an active operation on Google, upon reaching the specified location, it became evident that no such unit existed there. We inquired locally but were unable to locate the facility. Unfortunately, despite exploring nearby areas, we were unable to find any trace of the mentioned manufacturer. Consequently, this visit was deemed unsuccessful, as it did not yield any substantial data.

The third visit was arranged at Alif Oven Manufacturers situated in Ghatkopar. Upon arrival, it was noted that the location indicated on Google Maps was for their office rather than the manufacturing unit. A representative responsible for managing records was available for discussion. While valuable information regarding oven capacities, costs, and the extent of their national and international supplies was obtained, crucial questions remained unanswered. Instead, a brochure containing details about the ovens was provided, along with instructions to contact the sales unit for any further inquiries.

After the visit to Alif Oven Manufacturers, the team proceeded to Besto Oven Manufacturers, relying on the location provided by Google. However, upon arrival, it was discovered that the unit had permanently closed down. Consequently, this visit was deemed unsuccessful as it did not yield any relevant data.

Finally, a visit was made to Ami Oven Manufacturers in Goregaon. It was clarified that they specialize in the production of small electric ovens rather than the large ovens typically used in bakeries. Specifically, they focus on the production of lower motors for these ovens.

Table 7: Manufacturers visit

MANUFACTURER	LOCATION	STATUS
Naik Oven Manufacturers	Thane	Operational
Alif Oven Manufacturing Office	Ghatkopar	Operational
Besto Oven Manufacturers	Govandi	Permanently Closed
Abcon Oven Manufacturers	Govandi	Permanently Closed
Ami Oven Manufacturers	Goregaon	Operational

5.10.1. NAIK OVEN MANUFACTURERS

Information obtained from NAIK Ovens are as follows:

- Naik Oven Manufacturers produce various oven types based on capacity.
- They use LPG or diesel as fuel, with a preference for LPG due to lower maintenance efforts.
- LPG cylinders of 14-19 kgs are utilised and arranged into racks supplied by either cylinder suppliers or the manufacturer.
- Preheating typically lasts about 20 minutes.
- Indirect heating is employed, with fuel generating heat distributed uniformly via an internal fan.
- The company offers maintenance services, including servicing and replacement.
- On-site visits are provided to assess oven size, space management, and installation blueprints.

- Electricity consumption is charged at commercial rates, with an average of about 1/2 units (horsepower) daily.
- PNG is cited as more cost-effective compared to LPG and diesel, with electricity rates dependent on commercial providers.

It was evident from the manufacturer visits that these manufacturers lack a marketing department that tends to connect with these bakery owners and explain to them the benefits, ease of operation, and availability of service to provide maintenance and support. This gap results in a lack of awareness among bakery owners about modern, energy-efficient baking technologies and their advantages. Without dedicated marketing efforts, manufacturers miss opportunities to educate potential customers on cost savings, improved product quality, and enhanced operational efficiency that can be achieved through adopting advanced equipment. Consequently, the adoption rate of new technologies remains low, hindering overall progress toward energy efficiency and sustainability in the bakery industry. Addressing this gap through targeted marketing strategies and effective communication channels can significantly influence the modernization and environmental impact of bakery operations.

5.11 DISCUSSION

5.11.1. COST-BENEFIT ANALYSIS OF THE AVAILABLE OPTIONS

The economic feasibility of using various fuels in bakeries is examined primarily based on fuel costs in this report. Currently, a prevalent practice among a considerable number bakeries across Mumbai is the use of wood, particularly scrap wood, as the primary fuel for baking. Despite the evident air pollution concerns associated with wood combustion, it remains the preferred choice among bakery owners due to its high cost-effectiveness and reliability. Additionally, its ease of handling makes it particularly attractive for bakeries often staffed by unskilled migrant labour, commonly from Uttar Pradesh. However, transitioning to cleaner fuel options such as electricity and PNG (Piped Natural Gas) appears to be the most viable solution to mitigate air pollution from bakery operations, as indicated by the cost-benefit analysis presented in this report.

Nevertheless, barriers exist to the widespread adoption of cleaner fuels. The current cost of diesel stands at Rs. 92.15 per litre, while firewood ranges from Rs. 12 to 15 per kg and scrap wood from Rs. 2 to 5 per kg. Commercial LPG cylinders, weighing 19kg, cost around Rs. 1717, and PNG is priced at approximately Rs. 57.31 per SCM (Standard Cubic Meter). Although electricity costs vary across providers, precise figures remain elusive. According to insights shared by bakery owners, transitioning to electricity results in a threefold increase in the payable bill amount compared to the cost of firewood for the same level of production. Similarly, the high costs associated with diesel and LPG pose significant challenges for bakery owners considering a shift to cleaner fuel alternatives.

Furthermore, the acquisition, installation, and maintenance of air pollution control equipment present additional economic burdens for small bakery businesses, which often operate on tight profit margins. Consequently, while cleaner fuels offer potential solutions to mitigate air pollution, economic constraints and operational considerations hinder their widespread adoption within the bakery industry.

Table 8: Cost-Benefit Analysis

Bakery Industry emissions										
Costing & Emissions derivation 100 kgs of flour per day										Date: 3.9.2024
Fuel type	**Wood + scrap wood**		**LPG**		**Diesel**		**PNG**		**Electricity**	
			625000	Kcal /Kg	625000	Kcal /Kg	625000	Kcal /Kg	625000	Kcal /Kg
Consumption	250	Kgs/ day	52.3	Kgs /day	62.5	Kgs /day	73.5	Scm/day	726.7	Kwh/day
CV	2500	Kcal /Kg	11950	Kcal /Kg	10000	Kcal /Kg	8500	Kcal /scm	860	Kcal/ kwh
Energy required	625000	Kcal /Kg	1685	Rs / 19 Kg	94	Rs/litre	57.31	Rs/Scm	10	Rs /Kwh
Avg. Cost	10	Rs /kg	89	Rs / kg	76.2	Litres/day	-		-	
Total cost	2500	Rs/ day	4639	Rs/ day	7165	Rs/ day	4214	Rs/ day	7267	Rs/ day
Total cost / kg of flour	**25**	**Rs/ Kg flour**	**46.4**	**Rs/ Kg flour**	**71.6**	**Rs/ Kg flour**	**42.1**	**Rs/ Kg flour**	**72.7**	**Rs/ Kg flour**
Total emissions (NOx+SOx+CO)	**32**	**Kgs/ day/ unit**	**0.13**	**Kgs/ day/ unit**	**1.57**	**Kgs/ day/ unit**	**0.243**	**Kgs/ day/ unit**	**-**	
HAPs (PM 2.5)	3	Kgs/ day/ unit	0.11	Kgs/ day/ unit	0.08	Kgs/ day/ unit	0.14	Kgs/ day/ unit	-	
HAPs (PM 10)	4	Kgs/ day/ unit	-		0.11		-		0.0026	Kgs/ day/ unit

Table 9: Estimated Emissions of All Fuel Types

Emissions	Wood		LPG		Diesel		PNG		Electricity	
Average fuel consumption	250	Kgs/day	52.3	Kgs/day	76.2	Litre/day	73.5	Scm/day	726.7	Kwh/day
SPM (Suspended Particulate Matter)	-	-	-	-	-	-	-	-	-	
Total Avg. emissions (PM 10)	4	Kgs/ t/ day	-	Kgs/ t/ day	0.11	Kgs/ KL/ day	-	Kgs/ scm/ day	-	Kwh/day
Total Avg. emissions (PM 2.5)	3	Kgs/ t/ day	0.11	Kgs/ t/ day	0.08	Kgs/ KL/ day	0.14	Kgs/ scm/ day	-	Kwh/day
SO_2	0.05	Kgs/ t/ day	0.02	Kgs/ t/ day	1.31	Kgs/ KL/ day	0.000809	Kgs/ scm/ day	-	Kwh/day
NOx	0.325	Kgs/ t/ day	0.09	Kgs/ t/ day	0.21	Kgs/ KL/ day	0.162	Kgs/ scm/ day	-	Kwh/day
CO	32	Kgs/ t/ day	0.01	Kgs/ t/ day	0.05	Kgs/ KL/ day	0.081	Kgs/ scm/ day	-	Kwh/day
Daily emissions	32	Kgs /day	0.13	Kgs /day	1.57	Kgs /day	0.243	Kgs /day	-	

INFERENCE OF THE AVAILABLE OPTIONS (Table 8)

1. Wood and scrap wood emerge as the most cost-effective fuel options for bakeries, offering lower per kg flour costs compared to LPG, PNG, and electricity. It is the most polluting in terms of emissions both NOx + SOx + CO and Particulate Matter.
2. LPG, despite its higher energy efficiency indicated by calorific values, result in higher overall costs due to comparatively higher fuel prices.
3. PNG will be the most economical choice for bakery owners due to its comparatively lower price than all other cleaner fuel choices.
4. Electricity is the costliest option, with the highest per kg flour cost among all fuel options considered, making it an unacceptable choice for bakery operations.

EMISSION ESTIMATION OF ALL THE AVAILABLE FUEL CHOICES (Table 9)

Table 9 provides a comparison of emissions across five sources: **Wood**, **Diesel**, **LPG**, **PNG**, and **Electricity**. Each fuel type's environmental impact is measured in terms of daily consumption, particulate matter, sulfur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), and total daily emissions.

1. **Average Fuel Consumption:**
   - Wood requires the highest quantity in terms of mass (250 kg/day), reflecting its lower energy density. Compared to cleaner fuels, more wood is required to produce the same energy output.
   - LPG, Diesel, and PNG have much lower consumption rates in their respective units, as they are more efficient energy sources.
   - Due to the cost and the amount of electricity required (726.7 Kwh/day), electricity becomes the costliest option.
2. **Suspended Particulate Matter**
   - Wood burning produces the highest particulate emissions (PM_{10} (4 Kg/ton/day), $PM_{2.5}$ (3 Kgs/ton/day)), a major source of air pollution contributing to respiratory diseases and environmental degradation.
   - Diesel, while being a liquid fuel, still produces particulate emissions due to incomplete combustion, but at much lower levels compared to wood.
   - While the other fuels don’t produce a significant amount of Particulate Matter (electricity produces zero PM).
3. **SO_2 (Sulfur Dioxide)**
   - Diesel produces far higher SO_2 emissions compared to all other fuels (1.31 kg/day).
   - Wood has moderate SO_2 emissions (0.05 kg/day).
   - PNG (0.000089 kg/day) has almost negligible SO_2 emissions, making it the cleanest fuel in this regard.
   - LPG (0.02 kg/day) also emits very low levels of SO_2.
4. **NOx (Nitrogen Oxides)**
   - Wood (0.325 kg/day) produces the highest NOx emissions.
   - Diesel, PNG, and LPG also produce moderate levels of NOx, but lower than wood.
5. **CO (Corbon Monoxide)**
   - Wood produces an enormous amount of carbon monoxide (32 ks/day).

- LPG is the cleanest in terms of CO emissions, with almost no CO emissions (0.01 kg/day).
- Diesel (0.081 kg/day) and PNG (0.08 kg/day) produce very low levels of CO compared to wood.

6. **Total Daily Emissions**
   - **Wood** has the highest total emissions (32 Kgs/day), followed by **diesel** (1.57 Kgs/day). Wood's high emissions are due to its inefficient combustion process, contributing to large amounts of CO, NOx, SO2, and particulate matter. Diesel, although more efficient, still has high emissions due to SO2 and NOx.
   - LPG and PNG are far cleaner, with much lower emissions, making them more environmentally friendly choices.

Conclusion:

- Wood is by far the most polluting fuel in almost every category, with extremely high emissions of CO, particulate matter, NOx, and moderate SO2 levels.
- Diesel is a major polluter in terms of SO2 and NOx, though its CO and particulate emissions are lower than wood.
- LPG is the cleaner option with the lowest emissions across all categories.
- PNG is a clean and efficient fuel, with very low emissions of SO2 and moderate emissions of NOx and CO.
- Electricity's emissions depend on the source of generation, though it is likely cleaner if generated from renewable sources like solar or wind.

5.11.2 OBSTACLES IN ADOPTING CLEANER FUEL ALTERNATIVES

During discussions with bakery owners currently utilizing wood as fuel, several consistent hurdles to transitioning to cleaner fuel alternatives like electricity, PNG, and LPG were highlighted.

- Foremost, wood and scrap wood were noted to be significantly cheaper compared to electricity, LPG, and PNG, presenting a major cost barrier.
- Additionally, the ease of handling wood was emphasized, particularly due to the employment of unskilled labour in bakeries, making it a preferred option.
- Space constraints emerged as another significant challenge, with concerns regarding accommodating ovens and the additional expenses associated with maintenance and repair.
- Moreover, the reliability of wood was raised as another critical aspect, as power cuts or failures could disrupt production, impacting both production efficiency and sales.
- Another consideration mentioned was the perceived superior taste of bakery products baked using wood, which tends to attract more customers than those baked using other fuels.

- It was observed that pipelines for gas supply (LPG/PNG) are impractical for bakery usage in slum areas because of the limited space and densely packed settlements without any gaps in between.

Table 10: Reason of bakeries apprehensive to transition

REASON	NO. OF BAKERIES
Costing	**76**
Costing + flavours	**12**
Flavours	**5**
Lack of information/training	**63**
No response	15
Closed Bakeries	26
Retail shops	16
3 bakeries that willingly participated in the survey informed that they transitioned to electricity taking into consideration the locality and hygiene purposes.	

Several reasons contribute to bakeries' apprehension (Table 9) about transitioning to cleaner energy sources. Cost is the primary concern for 76 bakeries, while 12 were worried about both cost and flavour changes, and 5 were concerned solely about flavour. Additionally, 63 bakeries lacked information and training, 15 did not respond, 26 were closed, and 16 were retail shops. These barriers highlight the need for targeted efforts to address economic, informational, and operational concerns to encourage the adoption of cleaner energy practices.

5.11.3 EMISSION ESTIMATIONS OF SURVEYED BAKERIES:

Emissions (kg/d) = No. of Bakeries x Fuel Consumption (kg/d) x Emission Factor

Number of registered bakeries with MCGM = 560

Number of total registered bakeries (according to our calculation) = 628

Number of total bakeries surveyed = 216

Number of surveyed bakeries using wood = 72

Wood consumption in a day = 130 (kg/d/oven) x 2 Ovens = 260 kg/day

Diesel consumption in a day = 80 (liters/day)

Wood Burning Emissions

Emission Factor for Wood Burning = 17.3 (kg/tonnes) (PM_{10})

Given that each bakery uses 260 kg of wood per day, $PM_{2.5}$ emissions from 72 bakeries.

Total annual wood consumption per bakery: 260kg x 365 days = 94,900kg/year

Annual wood consumption to tonnes = 94,900 kg/year÷1000 kg/tonne = 94.9tonnes/year

For PM_{10},

Emissions of PM_{10} (tonne/year) = 72 x 94.9 x 17.3

Emissions of PM_{10} (tonne/year) = **1,18,207.44**

For $PM_{2.5}$, $PM_{2.5}/PM_{10}$ = 0.68

Total $PM_{2.5}$ emissions = Emissions PM10 x 0.68

Total $PM_{2.5}$ emissions (tonne/year) = 1,18,207.44 x 0.68

Total $PM_{2.5}$ emissions (tonne/year) = **80,381 kg/year**

Diesel Burning Emissions

Emission Factor for Diesel Burning = 0.25 (kg/kl) (SPM) -60% PM10

Emission from diesel-burning (PM_{10}) = 2 x (80/1000) x 0.25 = **0.04 (kg/d)**

Emissions from LPG and Electricity

Emission from LPG burning (PM) per day = 32 x (5.43/1000) x 2.10 = 0.364 kg/d

Emission (PM_{10}) from Electric heating = 102 x 0.000025 (kg/per Unit) = **0.0026 (kg/d) -------------(4*)**

**Bakery emission factors of various fuels used referred from (4)*

The emissions analysis shows that the 72 surveyed bakeries using wood emit 118,207.44 kg/year of PM_{10} and 80,381 kg/year of $PM_{2.5}$. Diesel-burning bakeries produce 0.04 kg/day of PM_{10} while LPG-burning bakeries emit 0.364 kg/day of PM. Electric heating results in the lowest PM_{10} emissions at 0.0026 kg/day. This data highlights the significant particulate matter emissions from wood burning compared to much lower emissions from diesel, LPG, and electric heating.

5.11.4 UNDERSTANDING THE HEALTH IMPACTS ON BAKERY WORKERS

Bakeries, often bustling hubs of activity, are not only centers of culinary creativity but also environments where workers are exposed to various occupational hazards. Bakery workers face multiple occupational hazards including exposure to particulate matter, heat and humidity, chemicals, ergonomic risks, allergens, hot surfaces, and poor indoor air quality, which can lead to respiratory issues, discomfort, heat-related illnesses, musculoskeletal disorders, allergic reactions, burns, and other health problems if not properly managed. Among these hazards, respiratory health risks loom large, with professional asthma being a frequently reported work-related respiratory ailment among bakery workers. Immunologic sensitization to $PM_{2.5}$ can trigger allergic reactions in the airways, contributing to conditions such as chronic bronchitis and impairment of pulmonary function. Short-term exposure to $PM_{2.5}$ can result in immediate respiratory symptoms such as a runny nose, runny eyes, wheezing, sneezing, coughing, and shortness of breath. However, prolonged or long-term exposure to this, poses even greater risks, potentially leading to the development of occupational asthma, commonly referred to as baker's asthma. Occupational asthma is a chronic respiratory condition characterized by inflammation and narrowing of the airways, which can significantly impact the quality of life and long-term health of affected individuals (23).

In a recent study involving bakery workers, a range of respiratory symptoms was identified. While none of the participants were smokers or had a history of asthma, pneumonia, nasal allergies, or persistent phlegm, two workers had a past tuberculosis history, one of whom experienced daily cough and wheezing. Additionally, nearly all workers experienced rhinitis in the past year, and one reported eczema. A notable finding was that thirteen workers admitted to breath-catching while walking, with biomass workers showing heightened susceptibility. Further analysis revealed biomass bakery workers had significantly higher odds of breath-catching compared to electric bakery workers (23).

Apart from respiratory concerns, exposure to hazardous compounds presents another significant health challenge for bakery workers. Chemical reactions during baking processes release formaldehyde and acetaldehyde into the air, with elevated exposure levels observed in bakery workplaces, particularly during the leavening phase. Factors such as ventilation, room size, and production processes play crucial roles in determining exposure levels (24).

Commercial bakeries can contribute to air pollution through the emission of Volatile Organic Compounds (VOCs), primarily stemming from the operation of their ovens.

5.11.5 VOLATILE ORGANIC COMPOUNDS

The emission of Volatile Organic Compounds (VOCs) from various sources, particularly prevalent in settings with abundant furniture units, poses significant challenges to air quality. These emissions stem from the use of adhesives and coatings such as paints, varnishes, waxes, and solvents. Solid wood and wood composite-based furniture units are noteworthy contributors to VOC emissions. The impact of these emissions on human health, especially concerning vulnerable populations like children, is of growing concern. Health risks associated with VOC exposure range from acute effects like irritation of the eyes, nose, and throat to chronic issues including respiratory problems, immunodeficiency, and neurological disorders (25).

Specifically, formaldehyde emissions from urea formaldehyde (UF) glue used in composite wood products have been studied extensively. Elevated temperature and humidity conditions exacerbate formaldehyde emissions, even after long-term storage under standard conditions. Additionally, the combustion of flexible polyurethane foam (FPUF) poses significant risks due to the release of carbon monoxide (CO) and hydrogen cyanide (HCN) in fires (26).

Epoxy resin, when subjected to thermal decomposition, generates various gaseous by-products beyond CO and CO_2, including methane, ethylene, and nitric oxide. The combustion of epoxy resin can emit VOCs such as bisphenol A (BPA) and epichlorohydrin, contributing to air pollution and potential health risks (27). Similarly, the combustion of polyvinyl acetate (PVA) glue may release acetic acid, formaldehyde, and various VOCs, adding to air pollution and posing potential health risks.

Moreover, burning domestic wood treated with PVC coatings on furniture can lead to the emission of pollutants like polychlorinated dibenzo-p-dioxins dibenzofurans (PCDD/F). These emissions exceed regulatory limits, especially when halogenated materials like PVC-coated plywood are burned. Mitigation measures are necessary to address the health and environmental risks associated with burning PVC-coated wood (28).

Table 11: Volatile Compounds from scrap wood

Glue Type	VOCs Released	Environmental Impact	Health Risks	Purpose of Use
Urea-formaldehyde (UF)	Formaldehyde, acetaldehyde, methanol	UF emits high levels of formaldehyde, exacerbated by elevated temperature and humidity; contributes significantly to air pollution	Eye, nose, and throat irritation; respiratory issues; potential neurotoxic effects; potential carcinogenic effects	Low-cost, water-resistant adhesive for plywood furniture
Phenol-formaldehyde (PF)	Formaldehyde, phenol, benzene	Releases formaldehyde, phenol, and benzene, albeit lower compared to UF; still poses health risks and contributes to air pollution	Respiratory issues; potential carcinogenic effects; neurological effects	Strong, durable adhesive for plywood furniture
Melamine	Formaldehyde, hydrogen cyanide, ammonia, nitrogen oxides	Combustion releases noxious fumes including formaldehyde and cyanide; poses significant health hazards and exacerbates air pollution	Respiratory issues; potential neurological effects; eye irritation	Bonding plywood surfaces, offering scratch and stain resistance
Polyurethane (PU)	Carbon monoxide, hydrogen cyanide, toluene	PU foam combustion releases toxic gases, including CO and HCN; endangers lives and worsens air quality; poses fire hazards	Respiratory issues; potential neurological effects; eye and skin irritation	Provides clear, glossy finish and enhanced durability
Acrylic and Catalyzed Lacquer	Formaldehyde, acetaldehyde, toluene, xylene	Emits various harmful compounds upon combustion, contributing to air pollution and posing health risks	Respiratory issues; potential carcinogenic effects; eye and skin irritation	Rapid-drying, transparent coatings for plywood furniture
Epoxy Resin	Formaldehyde, bisphenol A, epichlorohydrin, toluene	Releases formaldehyde, BPA, and other VOCs; adds to air pollution and poses health risks	Respiratory issues; potential endocrine disruption; neurological effects	Provides strong and resilient bonding for plywood and other materials
Polyvinyl Acetate (PVA)/ White glue/ Carpenters glue	Acetic acid, formaldehyde, ethanol, ethyl acetate	Releases acetic acid, formaldehyde, and other VOCs; contributes to air pollution and poses health risks	Eye, nose, and throat irritation; respiratory issues; potential carcinogenic effects	Strong bonding strength, transparent drying properties
Tung Oil	Acetic acid, formaldehyde, carbon monoxide	Emits VOCs including acetic acid and formaldehyde; impacts air quality and contributes to air pollution	Eye, nose, and throat irritation; respiratory issues; potential carcinogenic effects	Enhances wood's beauty and protects against moisture
PVC and PCDD/F	Polychlorinated dibenzo-p-dioxins, dibenzofurans, HCl	Burning releases PCDD/F, HCl, and other pollutants; requires mitigation to prevent health and environmental risks	Respiratory issues; potential carcinogenic effects; environmental contamination	Provides waterproof and durable coating for furniture

5.11.6 EFFECT OF SMOKE ON FINISHED BAKERY PRODUCTS AND RELATED HEALTH CONCERNS

Bakery products, particularly those subjected to high temperatures, pose significant health risks due to the formation of harmful substances. It has also been reported that when solid fuels are used for baking, carcinogenic substances get adsorbed onto the baked goods. Acrylamide, a potential carcinogen, forms during the baking process, especially in carbohydrate-rich foods like bread and pastries (29). Studies have linked acrylamide exposure to an increased risk of several cancers, including endometrial, ovarian, and kidney cancer (30). The Maillard reaction, responsible for the browning of baked goods, produces this compound, making it a common contaminant in a wide range of baked products.

The correlation between the consumption of smoked foods and the increased occurrence of cancer, particularly in the intestinal tract, has been identified by epidemiological studies (31). This concern extends to bakery products when solid fuels are used for baking, as the incomplete combustion of these fuels can produce similar carcinogenic compounds. The contamination of bakery products with BaP and other harmful pollutants from smoke emphasizes the need for cleaner baking methods to ensure food safety and protect public health.

Smoke from burning wood during baking can impart an undesirable smoky flavour and aroma to baked products due to compounds like phenols and guaiacol. It can also cause discoloration and uneven surfaces on the food. More concerning are the health hazards associated with wood smoke, which contains harmful chemicals such as polycyclic aromatic hydrocarbons (PAHs) and benzene, known carcinogens that can contaminate food. Inhalation of wood smoke can lead to respiratory issues, irritation of the eyes, throat, and skin, and an increased risk of cardiovascular problems due to fine particulate matter. These health risks emphasize the importance of transitioning to cleaner fuel alternatives in baking (32, 33).

5.11.7 MAJOR GAPS IDENTIFIED

- **CATEGORIZATION OF BAKERIES**

What Exists?? In 2023, the classification methodology established in 2016 by CPCB underwent modifications to better reflect environmental concerns by incorporating three key pollutant groups: water pollution, air pollution, and hazardous waste generation. Each of these groups is assessed on a scale of 0 to 100, with higher scores indicating greater pollution levels. This scoring system is pivotal in determining the classification of industrial sectors based on their environmental impact.

For air pollution assessment, the scoring process is detailed. It comprises three main components: the type of pollutants emitted (A1), the occurrence of fugitive emissions and odour nuisances (A2), and the type and quantity of fuel used (A3). These components are assigned weightage of 35%, 30%, and 35%, respectively. Sectors generating emissions containing hazardous air pollutants, exhibiting process-based fugitive emissions, and relying on polluting fuels receive higher scores due to their heightened potential for environmental harm.

Bakeries, typically unclassified by size, find themselves categorized by the Central Pollution Control Board (CPCB) concerning their pollution index (Figure 25). This classification hinges on their daily production capacity. The CPCB delineates four categories: Firstly, bakeries producing confectionery and sweets; secondly, those with a production capacity of one ton per day (TPD) or more; thirdly, similar establishments using cleaner or gaseous fuels while maintaining the same production capacity; and finally, bakeries with a production capacity of less than 1 TPD.

What needs to be done?? Tables 11 and 12 from the CPCB document classify bakeries, but this categorization overlooks several important factors that need to be considered for a comprehensive classification. Aspects such as raw material consumption, the size of the bakery, the number of employees, and operating hours should be included to establish distinct categories like small, medium, or large bakeries. This would ensure a more accurate and practical classification system.

Table 12: Pollution Index Range

Ranges of Pollution Index for different categories	
Pollution Index (PI)	**Category of industrial sector**
PI >/= 80	Red
55 < PI < 80	Orange
25 </= PI < 55	Green
PI < 25	White

Table 13: Category-wise distinguish

A1: Score based on pollutants in emission							
A2: Score based on fugitive emissions and odour nuisance							
A3: Score based on Fuel Quantity							
Air Pollution Score (A) =A1+A2+A3							
SR NO	**PARTICULARS**	**A1**	**A2**	**A3**	**A**	**OLD CATEGORY**	**NEW CATEGORY**
1	Bakery confectionery and sweets products						**Orange**
2	Bakery, confectionery, sweets with production capacity >/= 1 TPD	25	0	25	50	**Orange**	
3	Bakery, confectionery, sweets with production capacity >/= 1 TPD (using cleaner/gaseous fuel)	25	0	10	35	**Green**	
4	Bakery/ confectionery/sweets products (with production capacity < 1 TPD)	25	0	20	45	**Green**	**Green**
5	Bakery/ confectionery/ sweets products (with production capacity < 1 TPD using cleaner / gaseous fuels)	25	0	10	35	**Green**	

** All numerical data referenced herein originates from the document issued by the Central Pollution Control Board (CPCB).*

Scoring criteria for air polluting industries

Air Pollutant Group	Description	Score
Score A1:	**Score based on presence of pollutants in the emissions.** (Maximum of the following scores to be considered)	
A11	Presence of Hazardous Air Pollutants (HAPs), and heavy metals: HAPs (Phosgene, Benzene, Benzo[a]pyrene, Butadiene, Toluene Diisocyanate, Methylenediphenyl Diisocyanate, Ethylene Oxide, Ethylene Di Chloride, Acrylonitrile, Propylene Oxide), Dioxins & Furans, Asbestos, Polycyclic Aromatic Hydrocarbons (PAHs), HCN, Cd, Th, Hg, Sb, As, Pb, Co, Cr, Cu, Mn, Ni, V, etc.	35
A12	Presence of halogens, acids and pesticides based pollutants: H_2S, HF, HBr, P_2O_5 as H_3PO_4, NH_3, TOC, Cl, HCl, SO_3, CH_3Cl, Total Fluoride, PM having pesticide compounds/other organic compounds, Acid mist, etc.	30
A13	Presence of pollutants due to combustion of fuel: PM, CO_2, CO, NOx, SO_2, etc.	25
A14	Presence of Volatile Organic Compounds (VOCs): Ethyl benzene, Styrene, Toluene, Xylene, Aromatics, Propylene Glycol, Ethylene Glycol, etc.	20
Score A2:	**Score based on fugitive emissions and odour nuisance.** (Maximum of the following scores to be considered)	
A21	Fugitive emissions of Particulate Matters (PM) due to process operations	30
A22	Fugitive emissions due to handling of materials, etc.	25
A23	Odour nuisance, including odour due to use of binding gums, cements, adhesives, enamels etc.	20
Score A3:	**Score based on the fuel quantity.** (Maximum of the following scores to be considered)	
	Coal or liquid fuels	
A31	Fuel consumption $\geq$ 24 TPD	35
A32	12 TPD $\leq$ Fuel consumption < 24 TPD	30
A33	Fuel consumption < 12 TPD	25
	Biomass-based fuels	
A34	Fuel consumption $\geq$ 48 TPD	25
A35	24 TPD $\leq$ Fuel consumption < 48 TPD	20
A36	Fuel consumption < 24 TPD	15
	Cleaner/gaseous fuels, such as, PNG, CNG, LPG, Compressed Bio-gas (CBG), propane, butane etc.	
A37	Fuel consumption $\geq$ 120 TPD	20
A38	60 TPD $\leq$ Fuel consumption < 120 TPD	15
A39	Fuel consumption < 60 TPD	10
	Air Pollution Score (A) =A1+A2+A3	
Note: In case, any sector/unit is using more than one type of fuel, the most polluting fuel category, will be consider		

Figure 25: Categorization of bakeries - snippet from CPCB directive (2016)

- **NEED FOR SPECIFIC EMISSION INVENTORY**

  Emission inventories are crucial for transitioning bakeries from wood to cleaner fuel alternatives. They quantify pollutants from wood combustion, highlighting bakery operations' environmental and health impacts, guiding alternative fuel evaluations, setting policy goals, and monitoring emission reduction progress. However, Mumbai's current inventory lacks a specific focus on scrap wood burning in bakeries, which differs significantly from those of tree wood. Reporting these emissions is essential for accurate assessment and tailored reduction strategies. Emission inventories that include scrap wood data provide transparent information, fostering collaboration among bakery owners, policymakers, and communities. This targeted approach ultimately supports sustainable development, mitigates air pollution, and safeguards public health in the bakery industry.

5.11.8 WAY FORWARD

- Engaged in productive discussions with key stakeholders, including Joint Director, Air, Maharashtra Pollution Control Board and Deputy Municipal Commissioner, Environment, Municipal Corporation of Greater Mumbai.
- Conducted separate meetings with the above-mentioned stakeholders featuring presentations on our findings.
- Outlined future strategies and a roadmap for enhanced directive implementation to curb the emissions arising through solid fuel burning.
- Proposed a project aimed at training municipal corporations and councils for effective directive compliance.
- Deliberated on short-term and long-term actions, stressing comprehensive coverage of all solid fuel combustion sources across MMR.
- Emphasized the importance of future legislation during discussions.

5.11.9 SUGGESTED ACTION POINTS

- Conduct sector-wise cost analysis to facilitate timely implementation involving industry, transport department, and urban local bodies.
- Acknowledge the established public health costs attributed to air pollution, emphasizing that controlling pollution at its source outweighs these costs.
- Implement a proactive, reward-based approach to public participation in select wards to set examples of successful air quality management.
- Establish a dedicated administrative structure and team for day-to-day data collection, analysis, and ground-level control of pollution sources.
- Monitor progress and resource pooling over the next 5 to 10 years through collaboration among multiple agencies (MPCB, MCGM, RTO, Fire Brigade, IoRs, Research Institutes, and Industries).
- Integrate satellite data into mainstream analytical tools across Maharashtra through collaborations with ISRO, IMD, and National Remote Sensing Agency.
- Digitize ward-based inventory to include sources from the unorganised sector, facilitating comprehensive database management.

CHAPTER 6: POLICY FORMULATION

Mumbai's bakeries situated within dense residential areas are the lifeline of the city's daily bread, an essential commodity under the Essential Commodities Act (ECA) of 1955. They churn out *'pav'*, a staple breakfast for the rich and poor alike. However, their reliance on traditional fuels contributes to air pollution directly affecting the residents living around it.

This report highlights the importance of transitioning of bakeries to cleaner alternatives and to achieve this critical shift, a policy incentivizing to enforce the adoption of cleaner fuels is being put forth.

This transition is also achievable considering the unspent amount of Rs. 373.74 crores of the National Clean Air Programme (NCAP) funds since FY 2019-20 to FY 2023 -24, which can be allocated to incentivize the transition to cleaner fuels amongst bakeries. This helps in tackling the source of pollution itself and ensuring there is no further pollution from this source. Investment into this transition is result oriented and achievable unlike the other sources where only mitigation efforts is possible eg. construction, vehicular pollution etc.

6.1 INITIATIVE OF MPCB

In a circular issued on 13th February 2024, the Maharashtra Pollution Control Board (MPCB) directed all Municipal Commissioners to take action to improve air quality by promoting the use of cleaner fuels in bakeries. (Annexure)

The circular highlights the following:

- The need to reduce Particulate Matter (PM) and odour emissions from bakery operations.
- Bakeries within the jurisdiction of the Municipal Commissioners must transition away from coal or wood-fired ovens.
- Bakeries are required to adopt cleaner alternatives such as Liquefied Petroleum Gas (LPG), electric ovens, and electric tandoors.
- To creating awareness among bakery owners regarding the benefits of switching to cleaner fuels. This includes ensuring that bakeries utilise electricity, gas, or smokeless fuels in their operations.
- Furthermore, it mandates a phased replacement of conventional fuel-based bakery operations with cleaner fuel alternatives within a one-year timeframe.

6.2 AIM OF THE POLICY

To offer handholding to the organised and unorganised sector and ensure that transition to cleaner fuel is not forced leading to closure and unemployment.

6.3 PHASE-WISE IMPLEMENTATION OF SWITCHING TO CLEANER FUELS.

I. Short term – (within 6 months)

a. To hold ward wise workshops for all the registered bakers within the Municipal corporation & council limits with an aim:
   i. To create awareness among bakeries in terms of health benefits and pollution impact associated with transitioning to cleaner fuels.
   ii. To conduct interactive sessions along with knowledgeable experts for giving an understanding of cleaner fuel options and means to switch.
   iii. Understanding the resistance to transitioning to cleaner fuels and providing solutions.
   iv. To involve Mahanagar Gas Limited (MGL) for Piped Natural Gas (PNG) and Oven manufacturers for a smooth supply chain in this process. The installation of PNG pipelines within slum areas should be funded through NCAP funds.
   v. To optimize ash disposal practices and ensure compliance with environmental regulations.

II. Medium term – (6 months to 1 year)

a. The initial focus of fuel transition efforts should be on registered bakeries, with the goal of converting them to electricity or Piped Natural Gas (PNG) based on source availability.

b. Within the registered category, large bakeries should be prioritized due to their potentially higher fuel consumption and emissions. Subsequently, medium and small bakeries can be addressed.

c. Addressing and resolving all issues or inconsistencies within the existing registration process for all the unregistered bakeries.

d. Provide cash incentives from NCAP funds to small, registered wood-burning bakeries to transition to sustainable fuels.

e. Offer subsidized raw materials, such as flour and sugar, to bakeries that exclusively produce pav or serve slum areas, contingent on their conversion to sustainable fuels.

f. Further studies to be initiated:

   i. Emission inventory study specific to scrap wood burning to be undertaken.
   ii. Proposal/ regulations for disposal of ash from the bakeries.
   iii. Framing of policy to deal with scrap wood.
   iv. Categorisation of bakeries: The CPCB's bakery classification system should consider various fuel types alongside production capacity. Bakeries using cleaner fuels like piped natural gas or electric ovens could qualify for a less polluting (green) category even if production exceeds 1 ton per day, as long as emissions meet green thresholds. This would incentivize cleaner operations and reduce air pollution.
   v. To develop labelling on packages for showcasing product type using cleaner fuels.

III. **Long term – (1 year to 2 years)**

a. Ensuring registration of all bakeries.

b. Compliance with zero percent of ash disposal in the open.

Hence, the transition of Mumbai's bakeries from traditional fuels to cleaner alternatives is a vital step towards reducing air pollution and improving public health. This policy formulation underscores the importance of a structured approach involving awareness, stakeholder engagement, and regulatory measures. The phased implementation plan, backed by the Maharashtra Pollution Control Board's directives and the availability of National Clean Air Programme (NCAP) funds, offers a clear roadmap for achieving this transition. By prioritizing workshops, fuel transitions for registered bakeries, and comprehensive studies, the policy aims to support both the organised and unorganised sectors, ensuring that the shift to cleaner fuels is smooth and sustainable. This initiative not only addresses a significant source of pollution but also sets a precedent for other sectors, contributing to a healthier urban environment and aligning with broader environmental conservation efforts.

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8. APPENDICES

A. ANNEXURE I: PICTURES

Scrap wood / waste wood being transported and used as fuel for baking

CHAMPION BAKERY

Freshly baked pav (other products include cookies, biscuits, cakes, khari, toast, butter)

Scrap wood being used as Fuel

Smoke emerging from chimney of Ahmadi Bakery (Byculla) during production of Pav

Chimney of Railway Bakery (Girgaon)

Figure 26: Bakery visits

Figure 27: Information brochure of Naik oven manufacturers, Thane, Maharashtra

Figure 28: Ovens at the manufacturing unit

Figure 29: Information brochure of Alif ovens, Ghatkopar

B. ANNEXURE II

SURVEY QUESTIONNAIRE

NAME OF THE BAKERY: ____

ADDRESS: ____

AREA: ____________________ **DATE:** ____

What is the specialty of our bakery's products?

a) Cakes b) Khari, Toast, Butter c) Bread d) Other ____________________________

What is the primary source of energy/fuel for baking in our bakery?

a) Electricity b) PNG c) Wood d) LPG e) Other ____________________________

Are there any secondary sources of energy/fuel used in our bakery for heating or cooking?

a) Yes b) No

What type of ovens do we primarily use in our bakery?

a) Electric ovens b) Gas ovens c) Wood-fired ovens d) Hybrid ovens e) Other ______________

Where do we typically source the fuel or energy used in our bakery?

a) Local suppliers b) National providers c) Specific locations d) Other __________________

Have we taken any steps to improve the energy efficiency of our bakery operations?

a) Yes b) No

If yes, please specify. ____

Are we considering any changes or upgrades in our bakery's energy sources or equipment in the near future?

a) Yes b) No

If yes, please provide details. ____

Have you observed any changes in the availability or cost of the energy sources we use for baking over the past few years?

a) Yes b) No

If yes, please describe. ____

What are the main factors we consider when choosing energy sources for our bakery's ovens?

a) Cost b) Environmental impact c) Reliability d) Other ____________________________

In the process of baking, do we use any specific resources or materials to enhance the flavour or texture of our products?

a) Yes b) No

If yes, please specify. ____

How do we manage and monitor the efficiency of our bakery's energy usage in daily operations?

a) Regular energy audits b) Real-time monitoring systems c) Employee training d) Other

____

What are the main challenges we face in ensuring a consistent and reliable energy supply for our bakery operations?

a) Energy price fluctuations b) Supply disruptions c) Environmental regulations d) Other

____

How do we manage our bakery's resource procurement, including any specific considerations for sourcing ingredients?

a) Local sourcing b) Sustainable practices c) Supplier relationships d) Other ________________

Are there any specific sustainable or environmentally friendly practices we follow in our bakery operations?

a) Yes b) No

If yes, please describe the sustainable practices we implement. ____________________________

IMP QUESTIONS TO BE ASKED

1) Are you considering transitioning to different fuel options for your bakery? If so, what are the motivations behind this decision, and which alternative fuel(s) are you exploring?

2) Besides the type of fuel, what other factors are influencing your decision to potentially switch from your current fuel type to another for the bakery?

3) If you're not planning to change your current fuel type, could you please explain why? What advantages does the current choice of fuel offer for your bakery?

4) Has your bakery used different types of fuel in the past? If yes, which types were used, and what led to the decision to switch to the current choice of fuel? Additionally, could you provide an approximate timeframe for when this transition occurred?

C. ANNEXURE III

QUESTIONNAIRE FOR OVEN MANUFACTURERS

1) What are the main benefits of using electric ovens compared to traditional fuel-powered ovens for bakery operations?
2) Can you provide details about the specifications of your electric ovens, such as size, capacity, energy efficiency ratings, and any special features relevant to bakery operations?
3) How does the cost of operating electric ovens compare to traditional fuel-powered ovens over the long term, considering factors like energy consumption and maintenance?
4) What level of reliability can bakery owners expect from your electric ovens, particularly in terms of consistent temperature control and overall performance?
5) Are there any incentives or support programs available to bakery owners who choose to invest in electric ovens as part of a transition to cleaner fuel options?
6) Can you discuss any technological advancements or innovations in electric oven design that improve efficiency, reduce emissions, or enhance overall bakery productivity?
7) Are there any challenges or limitations associated with using electric ovens in bakery operations that bakery owners should be aware of before making the switch?
8) Can you provide case studies or examples of bakeries that have successfully transitioned to using electric ovens, highlighting the benefits and outcomes of this transition?
9) What ongoing support or resources do you offer to bakery owners who choose to adopt electric ovens, such as training, maintenance services, or access to technical expertise?
10) Can you provide information on the current market trends and demand for electric ovens in the bakery industry, particularly in relation to the shift towards cleaner fuel options?
11) Are there any regulatory or policy considerations that bakery owners should be aware of when transitioning to electric ovens, such as energy efficiency standards or emissions regulations?
12) Can you discuss any potential challenges or barriers that bakery owners may encounter when transitioning to electric ovens, and what strategies can be implemented to address these challenges effectively?
13) Can you provide insights into the potential cost savings associated with proactive maintenance of electric ovens, such as reduced downtime, lower repair expenses, and extended equipment lifespan?
14) Are there any recommended maintenance schedules or checklists that bakery owners can follow to ensure comprehensive upkeep of their electric ovens, and how do these schedules vary based on usage patterns and environmental factors?
15) How do environmental conditions, such as humidity levels or temperature fluctuations, impact the maintenance requirements for electric ovens, and what steps can bakery owners take to mitigate these effects?
16) Can you discuss any emerging technologies or advancements in electric oven design that improve reliability and reduce the need for frequent maintenance interventions, such as self-diagnostic systems or predictive maintenance features?

17) Finally, how do maintenance considerations factor into the overall cost-benefit analysis for bakery owners evaluating the switch to electric ovens, and what resources or support mechanisms are available to help them make informed decisions in this regard?
18) What are the costs associated with electric ovens, their capacity, and what factors influence bakery owners' preferences regarding oven type?
19) Can you provide details on the approximate energy consumption and commercial cost of electricity or gas for bakery operations, and how these influence the choice between electric and traditional ovens?
20) Can you rank the heating methods from least to most expensive, and suggest the most suitable type of oven based on bakery requirements?

D. ANNEXURE IV

All wards of Mumbai and the corresponding areas.

Table 14: All wards of Mumbai and the corresponding areas

Ward	Areas Included
A	Cuffe Parade, Churchgate, Nariman Point, Colaba, Fort, Marine Lines
B	Sandhurst Road, Dongri, Umerkhadi, Bhendi Bazaar
C	Marine Lines, Dhobi Talao, Girgaon, Kalbadevi, Pydhonie
D	Malabar Hill, Grant Road, Mahalaxmi, Tardeo
E	Byculla, Agripada, Madanpura, Saat Rasta, Mahalaxmi
F/N	Matunga, Sion, Wadala
F/S	Parel, Sewri, Kalachowki, Cotton Green, Prabhadevi
G/N	Dadar, Mahim, Matunga
G/S	Worli, Lower Parel, Elphinstone
H/E	Bandra (East), Khar (East), Santacruz (East)
H/W	Bandra (West), Khar (West), Santacruz (West)
K/E	Andheri (East), Jogeshwari (East), Vile Parle (East)
K/W	Andheri (West), Juhu, Versova
P/N	Malad (West), Malad (East), Chincholi, Orlem
P/S	Goregaon (East), Goregaon (West), Bangur Nagar, Oshiwara
R/C	Borivali (East), Poisar
R/N	Dahisar (East), Dahisar (West)
R/S	Kandivali (West), Kandivali (East), Charkop, Poisar
L	Kurla, Sakinaka, Chembur (West), Asalpha
M/E	Chembur (East), Tilak Nagar, Mahul, Deonar
M/W	Chembur (West), Anushakti Nagar, Trombay
N	Ghatkopar (East), Pant Nagar, Garodia Nagar
S	Bhandup (East), Nahur, Vikhroli (East)
T	Mulund (West), Mulund (East)