Impact Evaluation of COVID19 Pandemic on Environmental Attributes

Conceptualized by

MAHARASHTRA POLLUTION CONTROL BOARD

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technogreen environmental solutions
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FOREWORD

The silver lining of anticipated environmental benefits amidst global outbreak of novel Coronavirus (COVID-19) has been brought to its scientific standing through enormous efforts of my entire team. On one hand, the standoff of this deadly virus becoming a health pandemic questioning the very survival of millions also poses the most pandemonium controversial affair when thought as Nature's Corrective Process. This deadly invisible enemy has affected almost every living being across the globe directly or indirectly causing nationwide complete lockdown that indeed posed tremendous opportunity to understand environmental sustainability at its core.

At the outset, it gives us immense pleasure in presenting you, first of its kind & thorough scientific compilation of "Impact Evaluation of COVID-19 Pandemic on Environmental Attributes" attempting correlation & apportionment of all major activities thought & known to alter environmental quality. Never before such humongous attempt is made to evaluate impacts on varying time line with multiple determinants & environmental attributes in one go which makes this environmental investigation extremely interesting. Though many of the assumptions & numbers can be debated for accuracy, the idea for this research is to create hope about Indian culture of finding positives in every Act of God.

This study is thought to be a credible addition to the scientific community and policy makers not only to assess the impacts of lockdown on quality of air, water etc., but also thought to provide for a base to strategically propose & evaluate corrective / alternative action plan towards environmental correction; as is the case with several countries including India for betterment of overall environmental quality & further to limit public exposure to extreme environmental conditions.

The Board is thankful to all concerned officials & other self developed portals by the Board for collating the data and useful information in time that enabled us to bring out this publication.

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Chapter I
COVID-19 Pandemic & India's Responsiveness – An Introduction

1.0 Introduction

Came 1st June & the so called period of Unlock Phase I, ending the last day of the 4th phase of lockdown implemented in the country to prevent the spread of Coronavirus infection. The 4th lockdown was imposed from 18th May to 31st May. Earlier, lockdowns were announced from 25th March to 14th April, 15th April to 3rd May and from 4th May to 17th May. This COVID-19 or Coronavirus has cast a global gloom by causing severe damage to health, the economy and general societal disruption. The entire world is facing economic & health crisis due the existing health pandemic caused through uncontrolled widespread community transfer of this virus.

The deadly Coronavirus outbreak is ever increasing in the country. In the 24 hours of May 31st 2020, 265 people have died, which is the largest number of deaths in a day. At the same time, the maximum 7964 new cases have also been reported on this Single day. Not only this, but 11,264 people have also been discharged from hospitals in this One day. According to the latest data of the Health Ministry, so far 1,73,763 cases have been reported as Coronavirus positive in India. At the same time where 4,971 people have died & 82,370 people have recovered from this infection.

Not known till recently to cause infections in human, this new infectious respiratory disease emerged in Wuhan, Hubei province, China & named as COVID-19 (Coronavirus Disease 2019) by World Health Organization. This new class of virus, known as SARS-CoV-2 (*severe acute respiratory syndrome* Coronavirus *2*) has been found to be responsible for over 58,19,962 confirmed global infection cases of COVID-19, including 3,62,786 deaths, as reported by WHO as of 30th May 2020.

1.1 The COVID-19 Chronology

As mentioned by the **UN Secretary General** in his **call for solidarity**, "We are facing a global health crisis unlike any in the 75-year history of the United Nations -one that is spreading human suffering, infecting the global economy and upending people's lives." He also added "We must ensure that lessons are learned and that this crisis provides a watershed moment for health emergency preparedness and for investment in critical 21st century public services and the effective delivery of global public goods. We have a framework for action; the **2030 Agenda for Sustainable Development** and the **Paris Agreement on Climate Change**. We must keep our promises for people and planet."

On 31st December 2019, Wuhan Municipal Health Commission, China, reported a cluster of cases of pneumonia in Wuhan, Hubei Province when this novel Coronavirus was eventually first identified. The World Health Organization declared the outbreak a Public Health Emergency of International Concern on 30th January, On 11th February 2020, WHO announced a name for the new Coronavirus disease: COVID-19 and a pandemic on 11th March. As of 31st May 2020, COVID-19 has infected over 5.5 million people in more than 188 countries & territories and claimed more than 3,50,000 lives with 80% cases in Europe United States overtaking China where the pandemic was initiated last December. The United Nations said the Coronavirus pandemic is the worst global crisis since World War II. In terms of the number of confirmed Coronavirus cases, the US, Brazil, Russia, Spain and UK are the five most-affected countries[1] as represented in **Figure 1**.

[1] *worldometer.com*

Figure 1 Global Statistic of COVID-19 as on 31st May 2020

1.2 Chronology in India

The Government of India confirmed India's first case of Coronavirus disease 2019 on 30th January 2020 in the state of Kerala, when a university student from Wuhan travelled back to the state. As the number of confirmed COVID-19 positive cases closed 500, Honorable PM Modi on 19th March, asked all citizens to observe 'Janata Curfew' (people's curfew) on Sunday, 22nd March. On 24th March 2020, the Government of India under Prime Minister Narendra Modi ordered a nationwide lockdown for 21 days, limiting movement of the entire 1.3 billion population of India as a preventive measure against the COVID-19 pandemic in India. Goal of this lockdown is “to contain the spread of Coronavirus outbreak in India" by banning on people from stepping out of their homes and closing of all services [excluding essential services], educational institutions, places of worships, commercial establishments, all types of industries excluding pharmaceuticals and Suspension of all non-essential public and private transport. On 30th May, it was announced that the ongoing lockdown would be further extended till 30th June in containment zones, with services resuming in a phased manner starting from 8th June. It is termed as "Unlock 1". An inventory and details of lockdown is as given below;

- Phase 1: 25th March 2020 – 14th April 2020 (21 days)
- Phase 2: 15th April 2020 – 3rd May 2020 (19 days)
- Phase 3: 4th May 2020 – 17th May 2020 (14 days)
- Phase 4: 18th May 2020 – 31st May 2020 (14 days)
- Unlock 1.0: 1st June 2020 – 30th June 2020 (30 days)

As on 31st May 2020, the total number of confirmed Coronavirus cases in India rose to 2,76,583 with 110,960 Active Cases, Recovered Patients are to the tune of 135,173 whereas deaths count to 7,745. India's top four metropolitan clusters - Delhi, Mumbai, Kolkata & Chennai, account for nearly half of the nationwide tally[2]. **Figure 2** shows status of COVID-19 outbreak in India with respect to total case, recovered cases and total deaths as on 31st May.

The first case of the COVID-19 pandemic in Maharashtra was confirmed on 9th March 2020. Maharashtra by now is a hotspot and virus spreader city on accounts for nearly one-third of the total cases in India as well as about 40% of all deaths[3]. As of 17th May, the state's case fatality rate is 3.6%, which is lower than the global average but significantly higher than other

[2] Hindustan Times: Updated 10 June 2020, 04:51 GMT+5:30
[3] *"Covid-19 state tally: Cases soar to 33,053 in Maharashtra, nearly one-third of national total". Hindustan Times. 18 May 2020. Retrieved 18 May 2020*

Indian states with large numbers of cases[4]. Mumbai is the worst-affected city in India, with more than 20,000 cases[5]. More than two-thirds of the cases in the state have emerged from the Mumbai Metropolitan Region (MMR). **Figure 3** shows district wise status of COVID-19 as on 31st May 2020 in Maharashtra.

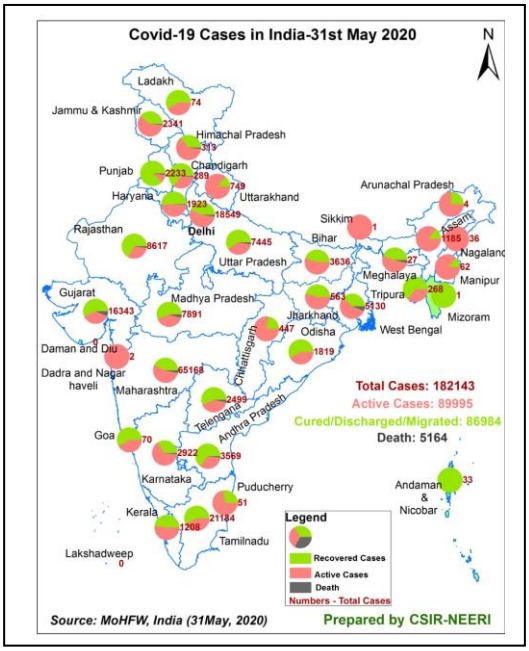


Figure 3 State wise status of COVID-19 as on 31st May 2020 in

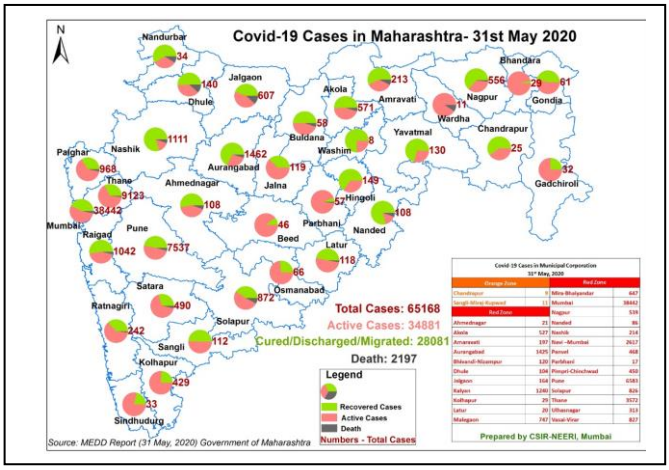


Figure 2 District wise status of COVID-19 as on 31st May 2020 in Maharashtra

1.3 The Responding India

Amid the COVID-19 pandemic, India responded in the most logical way to control the estimated and predicted worst case scenario to control community spread in the much early period by imposing country wide lockdown announced after a 14-hour voluntary curfew i.e. "Janata Curfew" on 22nd March, followed by a much targeted nationwide lockdown initially for three weeks starting from 24th March to 14th April 2020, extended up to 3rd May 2020 followed by further extension till 31st May as a 4th phase.

During the lockdown period, India witnessed and implemented strict restrictions on human to human contact thereby almost bringing the entire country to almost a halt with extremely limited essential services on the go. Nevertheless, such situation of country wide lockdown is perceived as environmental resetting phenomena by many is also significantly proved by witnessing significant positive changes visible across sectors of environmental parameters that are discussed throughout this report.

Essentially, the response from India was extremely quick & timely based on the worst case scenario predictions & experience from across the globe as presented by many of the nations that endured the ill impacts of COVID-19 & suffered uncontrollable spread ultimately resulting in impossible situations of coping up with this emergency. There was this dilemma of economics v/s health even in this situation of emergency wherein India responded with placing health as the prime concern with probable effective economic upliftment strategies for the times to come. Slowly & steadily, the phase of lockdown uncovered all those possible resumption of normalcy in a phased manner that forms the basis of all assessment & interpretation for the remaining part of this report. **Table 1** delineating all such allowed activities during each of the lock down phases as represented below.

[4] *"India sees highest 1-day spike with 5,242 coronavirus COVID-19 cases, total death toll till now at 3,029". Zee News. 18 May 2020. Retrieved 18 May 2020*
[5] *"2,347 COVID Cases In Maharashtra In 24 Hours, Mumbai Crosses 20,000-Mark". NDTV.com. Retrieved 18 May 2020*

Table 1 Consolidated Activities Permitted and Prohibited During National Lock Down

Activities	Lock Down 4.0			Lock Down 3.0				Lock Down 2.0	Lock Down 1.0	Janta Curfew
	Red Zone	Remaining Areas	Containment Zones	MMR, Pune, PCMC, Malegaon	Red	Orange	Green			
					Outside Containment Zones					
Travel - Air, Train, Metro	X	X	X	X	X	X	X	X	X	X
Interstate Road Movement	X	X	X	X	X			X	X	X
Educational Institute	X	X	X	X	X	X	X	X	X	X
Hospitality – Hotels	X	X	X	X	X	X	X	X	X	X
Shopping Malls, Market	X	X	X	X	X	√	√	X	X	X
Places of Worship & Large Gathering	X	X	X	X	X	X	X	X	X	X
Liquor Shops	Home Delivery	√	X	X	X	X	X	X	X	X
Age >65, <10, Pregnant-Outing	X	X	X	X	X	X	X	X	X	X
Medical Clinics, OPD	√	√	X		√	√	√			X
Taxi, Cab, Rickshaws	X	1+2	X	X	X					X
4 Wheelers	Ess.	1+2	X	X	X	Ess.	1+2		X	X
2 Wheelers	Ess.	1	X	X	X	Ess.	1		X	X
Inter-District Playing of buses	X	X	X	X	X	X	X		X	X
Intra-District Playing of Buses	X	√	X	X	X	X	X			X
Supply of Goods	Ess.	√	√	√	√	√	√			X
Industries – Urban	Ess.	√	X	Ess.+ IT Hardware	Ess.+ IT Hardware	Ess.+ IT Hardware	Ess.+ IT Hardware		X	X
SEZs, Export Oriented Units, Industrial Estates/ Township	NA	NA	NA	X	√	√	√		X	X
Industries – Rural	NA	√	X	X	√	√	√		X	X
Urban In-situ Constructions	√	√	X	√	√	√	√		X	X

Activities	Lock Down 4.0			Lock Down 3.0				Lock Down 2.0	Lock Down 1.0	Janta Curfew
	Red Zone	Remaining Areas	Containment Zones	MMR, Pune, PCMC, Malegaon	Red	Orange	Green			
					Outside Containment Zones					
Other Private Constructions Sites	X	√	X	X	X	X	√		X	X
Urban Standalone Shops	Ltd.	√	X	X	√	√	√		X	X
Essential Goods Shops	√	√	X	X	√	√	√			X
E-Commerce Essential Goods	√	√	√	√	√	√	√			X
E-Commerce Non - Essential Goods	√	√	X	X	X	X	X		X	X
Private Offices	X	√	X	X	33% Strength	33% Strength	33% Strength		X	X
Govt. Offices	5% Subject to Minm. 10	√ - 100%	X	X	√	√	√			X
Agri. Industries	X	√	X							X
Bank & Finance	√	√	X	X	√	√	√			X
Courier & Postal	√	√	X	X	X	X	X		X	X
Movement For Medical Emergencies	√	√	√							X
Barber Shops, Spa, Saloons	X	X	X	X	X	√	√		X	X
Stadium without Spectators	X	√	X						X	X
Home Delivery / Restaurants	√	√	X							X
Sub Registrar /RTO /DY /RTO	√	√	X	X	X	X	X			X

Chapter II
Activity Mapping of COVID-19 Pandemic Phases – An Environment Perspective

2.0 Background

As a result of combination of totally marginal human activities & lifestyle changes due to isolation & home quarantined situation for almost 70 days, with extremely limited & controlled exposure to ambient environment, let alone the movement of people related to essential services, it is quintessential to understand and map the activities in most probable manner in order to relate positive / negative changes in either of the social, economic or environmental fronts. Though several articles have been posted and published by CPCB on air quality and other such river improvement analysis during this period, the data seems to be only partly successful in presenting the classic case of the so perceived nature's restoration program.

2.1 The Conceptualization

Maharashtra through the visionary office of Maharashtra Pollution Control Board (MPCB) is taking a step further in order to explore possibilities to extend this perceived environmental changes even post normalcy as an attempt to continue & maintain environmentally sound conditions for betterment of human life.

Statistical validation of the data so collated during this period along with activity maps being superimposed for understanding cause-effect OR Event-Effect phenomena is the main objective of the MPCB study so reported here. Though it is a general perception that most of the pollution related activities were limited during this period such as vehicular movement on the road (except essential commercial / private vehicles), public transport being called off, closedown of commercial activities such as malls & theatres thereby changing lifestyle to completely the basic minimal living standards (consumerism changes), total shutdown / slowdown of construction & industrial units (except for the 1st degree medical & Pharma related units), is anticipated to surely have significant impact in terms of reduction in environmental pollution as goes the general expectations.

As lockdowns were implemented in response to the deadly Coronavirus *pandemic, the dramatic changes expected to be brought about by these restrictions have been described as the '**largest scale experiment ever**' into air quality. In India too, after many years, the blue sky can be spotted in normally hazy regions, as corroborated by satellite images, pollution data, and social media posts. This also magnetizes discussions regarding lockdown to be the effectual alternative measures to be implemented for controlling mainly air pollution but not limited to it since overall limited use of resource & equivalent restrictions in people's activity is expected to have positive impact on environmental attributes.*

However, the present environmental quality improvement in India dwells in irony. Amidst the devastating COVID-19 crisis, it is neither the time to rejoice clean air nor would one want air quality to improve this way in the future. Moreover, this clean environmental conditions phase is short lived and temporary. Some experts are concerned that environmental restrictions will be loosened to bounce back from the COVID-19 related economic losses.

It is equally important to also understand & base the understanding of the prevalent environmental conditions vis a vis activities during the so called Pre-COVID-19 also referred now as The Normalcy Period of Time i.e. till March 22nd 2020 as the basis of comparison of activity as well as environmental quality changes expected to have occurred and thereby correlate causal effects on important environmental aspects that may serve as an input in frame future policy interventions proposed to imitate and/or project conditions that reflect the COVID-19 phase anticipated improved environmental quality.

Chapter III
Objective Scope & Methodology

3.0 Objective & Scope

Even after the interim relaxation targeted to revive economy and survival of the downtrodden, it is estimated to take at least 3-6 months to bring life to normal &probably an year to recover economic slowdown so affected by this pandemic. Many say that this is natures balancing act is being witnessed by the world due to over exploitation of resources & crossing carrying capacity due to excessive anthropogenic activities. In many places, the halt of movement and industry has shown a **glimpse of a cleaner world**, with many reports of exceptional blue skies. However, visual perception alone can be deceiving when observing environmental pollution especially air pollution.

Overall the significance & impacts of lockdown are still not well understood and likely to have significant role on restoration of environmental quality, Nevertheless it also provides a unique opportunity to work in this direction to understand the upshot of lockdown measures on various parameters of environmental quality particularly when there is a need to implement such alternative control actions. *The present study is an effort in this direction to assess the usefulness of the lockdown as a strategic investigation for understanding changes in environmental quality in the State & the probable apportionment of sources. As a whole, the study is thought to be a useful supplement to the regulatory bodies since it may shows pollution source contributions towards specific environmental attribute especially for quantitative aspects like air emissions load, organic loads in surface water, bio-medical waste due to health pandemic as well as impacts of migration on MSW & so on.*

The concept of such humongous impact of COVID-19 posed several challenges that inspired MPCB to take up this study & made everyone involved to ponder up on & create an effective approach to resolve this hypothesis;

1. The pace of activities post COVID-19 will be multifold in order to revive & recover from the loses and to bring faster rate of coping up from economic perspective
2. The question still remains as to whether such revival of environmental conditions so to say betterment with absolute lockdown is the only way forward or there are ways & means to sustain these environmental conditions even post COVID-19 conditions
3. Are the concentration of pollutants in environment found as of now are background concentrations
4. If the above is true, whether reporting values till date were misleading since background corrections were not considered yet
5. What are the alternatives to sustain these environmental conditions post COVID-19 & post retrieval of activities known to add pollutants in environment such as providing for regular lockdowns to recover environmental conditions through masses – say weekly or so / mandatory work from home, no vehicle days,
6. What are the changes in resource patterns from point, area, line & fugitive source emissions
7. Whether primary data collection is possible to establish source receptor correlation
8. Can secondary data & engineering estimates be used to establish environmental betterment vis a vis source activities
9. What has been the rate of recovery of environmental conditions, if any
10. Understand graded patterns of recovery & individual source impact on the existing improvement of environmental conditions
11. Whether the cost of environmental improvement during these 30 days period of lockdown translating into assured environmental health benefits comparable to economic loss during this period of time (Green GDP?)

The idea is to understand the environmental clean-up (***as anticipated through the improved environmental scenario***) that is supposedly shaped due to the ongoing event of

COVID-19 & further to evaluate & account for prevailing environmental improved conditions to various barriers / restrictions on activities / source imposed due to lockdown.

Thereby, aligning the objectives of the present study as follows;

(i) Compare various aspects of environmental pollution in Maharashtra through various timelines of Pre & Phases of Lockdown
(ii) Map activities that can provide causal effect evaluation for changes in environmental attributes
(iii) Quantify & Correlate environmental quality throughout the State in tandem with the lockdown regulations & restricted activities
(iv) Unveil the Sustenance Options for creating alternative equivalence for various activities, if at all possible through source–impact matrix in order to provide strategic options for exponential activity expected to be speeded up post COVID-19

Focusing on the objectives, the study is thought to be a credible addition to the scientific community and policy makers not only to assess the impacts of lockdown on quality of air, water etc., but also its efficiency as corrective alternative action plan as practiced in several countries including India for improving overall environmental quality & limiting public exposure to extreme environmental conditions.

3.1 Methodology Adopted

Though is extremely important that primary data be gathered in order to be scientifically precise for such a critical analysis, yet restrictions during lockdown did not permit to effectively do so for each & every aspect. A simple & logically truthful methodology (*not limited to*) is presented in **Table 2** that not only attempts at gathering as much primary data as possible from existing network of MPCB / CPCB / researches but also attempts at devising ways of utilizing secondary information via collating available or invited data from various governmental & private organizations through effective channels of digital communication. Each of the sectors discussed in later sections in fact outlines a detailed methodology, data science / analytics, surrogate analysis approach, assumptions & limitations to the study to derive better confidence of the readers.

Table 2 Parameterization & Methodology for Assessment of Environmental Scenario during Pre & COVID-19 time periods

Environmental Aspect	Methodology
Defining timelines of study comparison & activities register	Enlisting of aspect – impact register along with timeline of events for which the impact shall be studied and evaluated. For example, • Initiation of slowdown and restrictions in movement during 10th to 22nd March • Followed by 23rd to 20th April as first phase of total lockdown • Then based on relaxations, if any time period between 20th to 3rd May & so on till 31st of May 2020 Preferably activity wise listing for entire Maharashtra State underlining the activity related to regulation of the government to enlist essential activities such as pharmaceuticals in Chemical zone of MIDC's, thermal power plants in certain parts of industrial zones, etc. Similarly, parameters of evaluation were selected from within the most applicable & expected impactful parameters such as industrial units active during various phases, water consumption in industries & commercial applications, electricity use in residential, fuel use in vehicles.

Environmental Aspect	Methodology
	Attempt were made to establish several surrogate analytical tools to understand behaviour as well as pattern of each source & expected impacts & also to generate baseline / COVID-19 activity data Most of the activity data are best guesstimates & every scientific / logical argument is presented to provide for best confidence in data gathered and analytical methods of interpretation used through transparent mechanisms.
Air Quality	MPCB online monitoring data for criteria pollutants is used to compare trends through various timelines as defined in consultation with team from MPCB & based on the final objectives as delineated in the due course of this study Vehicle data from Maharashtra State statistics websites & published government references used as baseline whereas estimates of non-restricted essential services of transport shall be evaluated and correlated using Google Urban mobility Area source inventory created using specific activity data for hotels, bakeries, street vendors vis a vis government regulations from time to time & overall emissions pattern for State using secondary data as baseline using existing published records of MPCB Inventory of various sources such as construction, bakeries, hotels, street vendors using sample data sets published in National Sample surveys & other researches / studies in past and extrapolating to meet present study objectives
Water Quality	Resource consumption from local authorities for industries using online portal of MPCB for industrial details, irrigation department / ULB's & other government agencies. Analysis of consumption pattern changes in residential areas due to lockdown, restricted movement & migration data superimposed Use of surrogate analysis to understand organic load reductions affecting river water quality due to restrictions on industrial release of water River quality information from MPCB for both baseline & primary data collection attempt through Regional Officers under the SWMP & NWMP
Solid Waste	Changes in Municipal Waste generation / disposal & issues therein for both urban & rural populations in light of migration Reduction in Hazardous waste & effective changes in transportation / handling due to industry slowdown Difference in Biomedical waste generation & handling issues with health pandemic

Environmental Aspect	Methodology
	Correlating commercial related [aspects of consumerism] consumption patterns with MSW & others.
Ecology & Sinks	Though not exactly the scope of this particular report, The study is expected to form basis for Estimations of reduced pressure on ecological sinks by using reduced pollution load data & sinks / environmental correction
Analysis of Alternatives to Sustain environmental conditions of present improved scenario	The study shall also help create Impact – Limitation Equivalence scenario of various alternatives such as by way of comparing fuel savings to vehicle km travelled OR wastewater generation to BOD / COD load released to rivers OR electricity saved in industries equivalent of coal / other fuels correlated to emissions therein & so on
Health & Economic Assessment	Improved environmental conditions to be translated into economic benefits for the State in order to also present cost benefits analysis through greening of GDP. Though extremely limited to the scope of this study, attempt shall be made to refer effective published documents as a source of secondary data
Sustenance Options	Interpret & Analyze activity restrictions & equivalent changes in environmental quality to pose as an alternative equivalence

Chapter IV
Baseline Environmental Quality [Pre- COVID-19 Scenario]

4.0 Preamble -Baseline Environmental Quality [Pre-COVID-19 Scenario]

As a first step in the environment impact assessment, it is necessary to evaluate, quantify & understand existing environmental attribute in an objective manner. These conditions when compared with the prevailing natural ambient environmental conditions, one can assess extent of pollution load, the quality parameters & type of environmental conditions prevailing in a particular area of discussion which in this case is entire State of Maharashtra. This baseline data serves as a point of reference to evaluate the impact of particular scenario which in this case is COVID-19 imposed restrictions. The background information so collated is also useful to delineate the merits as well as pros & cons of any activity anticipated to impart changes in environmental attributes. This chapter presents the existing baseline environmental status of State. The database for all environmental components is collected from primary monitoring stations as well as secondary database from MPCB.

Population x Affluence x Technology are the 3 basic fundamental pillars of lifestyle that has aggravated the problems of pollution over the past several decades. The problems of pollution (environment) are not unknown since long & there has been efforts to mitigate the same though may not have been prominently visible in day to day life. These problems can very well be classified into air, water, soil, hazardous & biomedical terms that includes altering of environmental attributes such as ambient air, surface & underground water bodies and environmental resources as a whole. Maharashtra has witnessed the gravity of environmental problems at a much faster pace than many of the other states in India due to rapid growth of industrialization leading to exponential growth of population therein. Though the growth rate of state is projected in **Table 3** wherein the infrastructure growth rate has seen deficit over a period of time thereby further intensifying the problem areas. This 3rd largest State of India in terms of area houses a population of 12.49crores[6] (2nd ranked in population) spread over an area of 3,08,000 km^2 with 36 districts, having an average population density of 365.00/km^2. The salient feature that brings Maharashtra in the top resource consuming State is that its GSDP has increased from 1,66,310 (Million Rs.) in 1980 to an estimated GSDP of about 21,54,446crore in 2018-19, it being 1st in coal & energy consumption with per capita energy consumption of 1083.7KWh[7].

Table 3 Annual Growth Rates of Real GSVA, Real GSDP and Per Capita Real GSDP As Per Advance Estimates of 2019-20

Sector	Growth Rate
1. Agriculture and Allied Activities [Agriculture, Forestery & Fishing]	3.1
2. Mining & Quarrying	0.0
3. Manufacturing	2.7
4. Electricity, Gas, Water Supply & Other Utility Services	6.4
5. Construction	6.1
6. Trade, Repair, Hotels & Restaurants, Transport, Storage & Communication & Services Related to Broadcasting	7.9
7. Financial, Real State 7 Professional Services	5.7
8. Public Administration, Defence & Other Services	12.7
GSVA	**5.7**
GSDP	**5.7**
Per Capita Real GSDP	**4.7**

Source; DES, GoM

[6] https://www.census2011.co.in/census/state/maharashtra.html)
[7] *Central Electricity Authority, GoI, MAHADISCOM, BEST, Reliance Infrastructure/ Adani Electricity, Tata Power Co. Ltd*

4.1 The State of Maharashtra Statistics

From the era of industrialization in Maharashtra, it has housed multifold industrial establishments which, at present counts to be 92,081 industries wherein, 13,936 are red, 27,719 are Orange, 42,884 are Green and 7,542 are white as per the CPCB categorization on the basis of pollution potential. In addition to these industries, there are 60,410 Health care establishments, 6,459 HW generating industries, 861 Plastic manufacturing units which are equally referred as pollution potential establishments in the State.

Nevertheless, there are 8 major thermal power stations generating about 21,176MW electricity along with other captive, non-conventional & hydro power stations totally amounting to 36,729MW (as of 31st March 2019) with a consumption share of 35.8% in industries, 25.6% in agriculture & 22.1% in domestic sector. The total coal consumption in Thermal Power plants with installed capacity of 36.7GW/d is 3.55Lakhs MTD. On the other hand, total vehicles registered in Maharashtra is 3,98,80,151 expected to travel 472cr kms across road length of 3Lakh km. Construction of about 5594acres/day is usually carried out in the State with loads of emissions from hotels, bakeries, street vendors using LPG, kerosene, wood & coal as fuels.

The state includes almost 3,01,000 kms of road network occupied by a provisional estimated 3.71crores[8] vehicles as of 1st Jan 2020 connecting about 97.77% of inhabited villages along with equally efficient rail & air network. The number of vehicles per km road length (roads maintained by PWD and ZP) in the State was 123 with about 30,398 motor vehicles per Lakh of population on road.

National Air quality Monitoring Programme (NAMP) implemented by MPCB assesses the present and anticipated air pollution through continuous air quality monitoring systems at 72 stations spread across 27 cities in the State as presented in **Table 4**.

Table 4 Ambient Air Quality Reported At Major Monitoring Stations During 2019

Monitoring Stations	Sulpher Dioxide [SO_2]		Nitrogen Oxides [NO_x]		Reparable Suspended Particulates Matter [RSPM]	
	Limit 80 µg/m^3		Limit 80 µg/m^3		Limit 80 µg/m^3	
	Min	Max	Min	Max	Min	Max
Mumbai - Sion	4	30	12	204	21	381
Pune - Swargate	22	50	25	138	61	210
Nashik - NMC Building	4	17	9	38	3	138
Aurangabad - CADA Office	7	24	22	65	49	97
Amravati - Govt. College of Engineering	4	16	9	18	22	102
Nagpur - Civil Lines	7	20	22	54	46	148

Source: MPCB µg/m^3: microgram per cubic meter

As per the NGT order no. 681 dated 8th October 2018, by the end of 2019, there were 18 critically polluted (Non attainment areas identified) along with 3 industrial areas categorized as critical zone for which detailed area wise action plans for reduction of air pollution is already in place.

On an average every day 23,700MT waste is generated in the State; of which about 88% is collected by going door to door. Scientific handling is available with almost all the Municipal Corporations with >90% efficiency. About 60% of the waste collected is segregated in the wet and dry form whereas 55% of collected waste is processed. Solid waste generated in the State is being treated in 56 common facilities provided either by Municipal Corporation or

[8] Office of the Transport Commissioner, GoM

Municipal Councils and 7 Cantonment Boards. Of the total solid waste generated, 52.9% Solid waste is treated per day. All 384 cities in the State have started the process of segregation. All 384 cities from the State participated in the Survekshan. In top 100 AMRUT rank holders, 29 were from Maharashtra. In top 100 non AMRUT rank holders, 83 were from Maharashtra. Out of 193 awards 46 were grabbed by Maharashtra which was highest by any state.

Additionally, the total quantity of plastic waste generated in Maharashtra is about 409,628.45MTA & through the banning of manufacturing & use of certain types of plastics & thermocol products, the GoM. During 2018-20, GoM seized about 1180MT of such banned materials though the State has a total capacity of 1,65,455TPA plastic recycling capacity operated through 31 such facilities.

Regulating 92,081 industries in the State, the total estimated effluent generation is about 403.69MLD of effluent. Since almost all the industries are listed on MPCB online portal & compliance is effectively monitored by MPCB all along the year with penal provisions for foul play, most of the effluents are treated to acceptable levels by industries themselves. Additionally, the scheme of CETP's for SSI units with complex effluent sources is already implemented (commissioned) in 25 industrial areas covering 7,860 industries. During 2018-19 effluent quantity treated on an average was about
173.82MLD.

With projected population of 12.49cr in 2020 in the States, computed sewage generation is around 9,759MLD. Treatment facilities are available mostly with the Class A & B ULB's that too to the extent of only 40% whereas otherwise mostly untreated sewage flows on to land in rural areas & river / sea in urban localities & on land disposal is the means in rural centers.

Hazardous wastes are wastes with properties that make them dangerous or potentially to human health or to the environment. In 2018-19 hazardous waste was generated during processing in 6,459 industries. Installation of Global Positioning System (GPS) for tracking of hazardous waste transporting vehicles has been made mandatory in the State. MPCB has authorized 182 hazardous waste transporters. Common facilities for management of hazardous waste have been set-up at four major sites, namely Taloja & Trans Thane Creek industrial areas of MIDC in Thane, Ranjangaon in Pune and Butibori in Nagpur. Total hazardous waste generated from 6,459 odd industries is about 360548.7MTD & are handled by 4 of the CHWTSDF using either of the processes including direct land filling, land filling after processing & incineration techniques

As per Bio-Medical Waste Management Rules - 2016, MPCB has started issuing authorization to Health Care Establishments (HCEs) for disposal of bio-medical waste. There are in all 60,410 HCEs under the purview of MPCB in the State upto December, 2018. The bio-medical waste generated from these HCEs is treated and disposed by 31 Common Bio-Medical Waste Treatment and Disposal Facilities; of which 29 are operating incinerations & remaining have deep burial facility. During 2019 on an average about 62.13MT bio-medical waste was treated and disposed off per day.

Though the quantity of E-waste generated is still to be inventoried in Maharashtra, MPCB has taken cognizance of the growing nuisance of E-waste thereby authorizing 73 recyclers with a capacity of 65,000MT/A.

An exhaustive discussion establishing correlation between more elaborate baseline environmental attributes is presented in **Chapter V.**

Chapter V
Impact Evaluation – Environment Perspective

5.0 Preamble -Impact Evaluation – Environmental Perspective

The question about COVID-19 pandemic being a godsend for human beings or not can't be defined yet, but it would seem to be one for the environment. Following the outbreak of the Coronavirus, many countries had adopted lockdown procedures that restricted people from moving out and for shops & other establishments to close down. India imposed a nationwide lockdown 1.0 to 4.0 to stop the impending spread of the novel Coronavirus. Travels across the globe have been suspended. Even travels within a country across state or provincial borders are closed. Local public transports, including train, metro, buses, metros & taxis have also been suspended.

In India especially, the preparedness and anticipation has led to all mass gatherings & public celebrations to be barred. Shopping malls and stores were asked to allowed to operate only for essential goods. Offices, educational institutions, factories and many such organizations have been closed indefinitely. Towns, villages and residential complexes, including condominiums and building societies have been advised to restrict the movements of residents around and "social-distancing" to maintain a threshold distance between two persons were introduced. With fewer vehicles on the road, reduction in consumption of petroleum products and reduction in power demand from the commercial and industrial sector, there has been drastic change in the environmental quality. The COVID-19 lockdown has perceived healing of our planet environment in a way never seen before in living history (*at least society's perception & certain published media reports*).

Conclusively, though there has been a positive impact on the environment due to the lockdown, there is fear that once people start travelling again or go back to doing what they have been doing & even more so with a higher pace to cover up time lapsed during this period, all the positive impacts so anticipated will soon disappear. However, it is quintessential to measure this impact in order to quantify its extent & reasoning (causal effect) for researchers & specifically policy makers so as to understand impact of human interference on the environment in the short- and long-term which would have been otherwise impossible without the COVID-19 event in place. This opportunity for environmental scientists is explored in this study encompassing almost all the aspects / attributes of environment & attempt is made to correlate chronology of events through series of analysis & quantification as delineated in following sections.

5.1 Activity Mapping during various Phase of Study

It is so very essential to understand & quantify activity wise data so as to be correlated with the environmental changes that are measured through the effective network of monitoring program run by State Pollution Control Board. It is envisaged that higher the activity details, better chances of correlation with environmental attributes and thereby an exceptionally detailed discussion on the quantification of activities is carried out as the most important part of this study which is further correlated with various phases of COVID-19 including the baseline.

Status of air quality issues along with the baseline activity that may be thought to be responsible for the baseline air quality during the Pre- COVID-19 period as discussed in Chapter IV. However, it is further important to quantify the conditions during each phase of the COVID-19 as stated in Chapter II and followed across the sections of these discussions.

5.1.1 Activity Mapping for Attributes Related to Air Quality

5.1.1.1 Industrial Activity

Maharashtra State houses about 1,00,000 industries[9] which as per Annual Survey of Industries 2017-18, the State is at the top position in terms of Gross Value Added (Rs. 2,64,903 crore) which is 18.0% of Gross Value Added at All-India level & 2nd position in number of workers & wages with share of 11.6% & 14.7% respectively. The State's share in the total approved industrial projects and total investment therein is 17.9% & 10.3% respectively with a booming 249 industrial projects with an investment of 26,540cr FY 2019. The State's share in All-India exports is about 24% with a share of Rs. 3,51,096cr. Exports from the State cover a wide range of products such as gems & jewellery, petrochemicals, readymade garments, cotton yarn, metal & metal products, agro-based products, engineering items, drugs & pharmaceuticals and plastic & plastic items[10]. As on December 2019, the registered industrial units in MIDC's of Maharashtra is 50,788 Nos. with a total investment of Rs. 1,94,011cr. employing about 15.08lakh people[11].

With reference to the data extracted from MPCB online portal based on registered units, 53,255 Nos. of consent to operate have been granted since the time the online information is available i.e. since 2016. Though there are about 90,000 such units that have been registered online, information for the purpose of this report is limited to only these 53,255 industries employing about 65,94,476 people during the pre- COVID-19 period i.e. the normal working production period before 21st March 2020. Interestingly, the data so used refers to the permissions granted & NOT the operational details which may be only a fraction of the total permissions obtained by industries & thereby it is most probable that the scenario analysis as projected in this report may be thought to compensate for all such variables & thereby computes the worst case presumptions.

Assumptions

- 53,255 industries represents Pre Covid whereas 9102 industries were permitted during as on Unlock 1.0 to evaluate industrial impact scenario in Maharashtra
- L1 represented by 2362 Nos. with essential industries
- L2 represented by 5372 Nos. with essential & allied industries
- L3 represented by 7414 Nos. with essential, allied & other permitted industries
- L4 represented by 9102 Nos. with all permitted & active industries in last phase
- Only permitted / consented quantities of fuel considered & not the actual use
- Actual operation details may be only fraction of the total permissions granted, thereby probably covering up for the missing information & assuming representation of whole of Maharashtra
- Permissions may not directly translate into operational status but it represents the worst case scenario

COVID-19 has impacted to the core of industrial activities including changes in working patterns, production quantities, material & energy consumption, employment engagement & almost all aspects of industrial footprints which by in itself can be correlated to the overall impacts on environmental behaviour due to industrial contribution of pollutant sources in terms of emissions load. However, it is essential to be able to conduct scientifically and valid process of assessing impacts & changes in the activities during pre & COVID-19 periods that is being attempted using certain engineering judgments & validation process articulated in this report.

At the same time, it is also essential to note that the methodology adopted to estimate activity changes pose certain limitations in terms of data availability, data cleaning, extraction, limited referencing during COVID-19 *period, surrogate analysis for extrapolation & data integrity in terms of use of only reported & assumed secondary available indicators.*

[9] Data from MPCB representing all the registered units extracted through the online portal
[10] Directorate of Industries, GoM
[11] MIDC, GoM

Data Science Theory

- Industrial activities data is extremely difficult to obtain in realistic terms since consented data is only an indicator of permitted resource quantities
- However, it is important to note that out of the 90,000 odd industries registered on MPCB online portal since 2016 onwards till date, all such industries falling within the category of Consents granted, Renewed & Operate / renewal in process are considered for computation purpose
- This does translate into accounting all details of about 53,000 odd industries for resource utilization in terms of these permits
- It also is a general practice to over apply for permissions by the industries considering the market volatility
- Thereby, the permitted quantities of fuel for these 53,000 industries may not be represent the true picture of real time utilization of fuel
- Such examples are evident with the fact that DG sets that are applied for consented capacity & fuel use of HSD / diesel may not be operational at all except for to be used as a backup source of power
- Thereby, over estimating the emissions load due to such limitations of data
- In fact similar issues shall also be encountered with permitted quantities of baggase for sugar & distillery industries since the actual production data cannot be retrieved during any of the study phase and poses a challenge in itself
- Many of the industries are switching to cleaner fuel and thereby apply for standby fuel due to extremely limited resource availability and assurance for fuel supply, thereby resulting into doubled quantification of such fuel
- Finally, engineering logic and extrapolation suggest that all the above mentioned facts shall compensate somehow to the industrial database adjustments for 90,000 industries that are permitted in Maharashtra State & also lack of real time resource consumption data may not defeat the very purpose of this exercise since the estimates of fuel are carried forward throughout the phases of study since the baseline of Pre-Covid conditions account for all the industries for which online data is available
- So let's say, 53,000 industries with effective rate of about 50-60% production capacities & thereby equivalent resource consumption may logically represent the entire 90,000 industries and their data basis.

Activity impact in order to understand industry variables correlated to air pollution directly have been considered mostly with respect to changes in the fuel consumption patterns due to reduced production expected out of the lockdown implementation across the State & other domestic variables such as utility use reductions, limited human activity in industry & so on.

Figure 4 represents industrial activity changes that are anticipated during various phases of lockdown based on use of products that were permitted qualifying as essential produce as well as their equivalent working population based on records provided by industries on MPCB portal.

It is extremely evident from the various reports across India that the COVID-19 lockdown has improved the air quality wherein Maharashtra too has witnessed similar trends over the past 3 months of this period. Though there are multiple source contribution towards ambient air quality, point sources i.e. stacks of the industries form one of the most discussed contributions towards ambient air quality and thereby the changes that have occurred during the period of lockdown needs to be evaluated in terms of changes in the emissions load to limited industrial activity as directly proportional to fuel consumption / combustion changes therein.

The data collated from industrial permissions across State of Maharashtra reveals a whooping fuel consumption pattern (in terms of consents granted for operations of industries till 2019) as the period of normalcy & the phase of changes as per permitted essential industrial produce

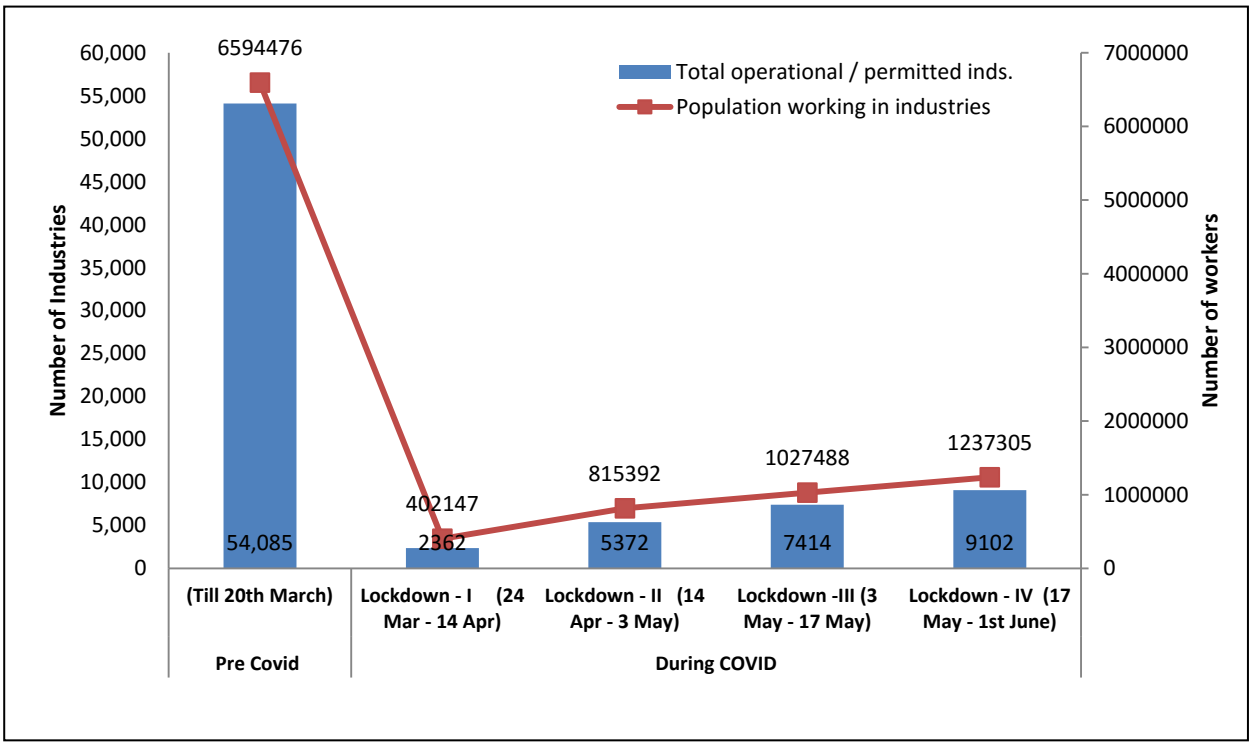


Figure 4 Anticipated industrial activity changes during various phases of lockdown

Coal is consumed to the extent of about 6 Lakh TPD whereas Natural Gas is favored in recent times with approximate permission for 100,000TPD. There are almost 10-12 different types of fuels that the industries have obtained permissions, of which some are clubbed together for ease of representation i.e. including LSHS, Diesel, LPG & Baggase especially since their quantities are miniscule amounting to about 21,000TPD together in addition to HSD & PNG which also has find its way to industries to tune of about 65,000TPD each whereas FO & LDO amounts to about 35,000TPD each. HSD, Briquettes & Wood forms a lowest portion of the total fuel use in industries to about 12,000TPD. Total fuel permitted is about 9.6 Lakh TPD though these may not always & daily translate to use by present worst scenario as represented in **Figure 5**

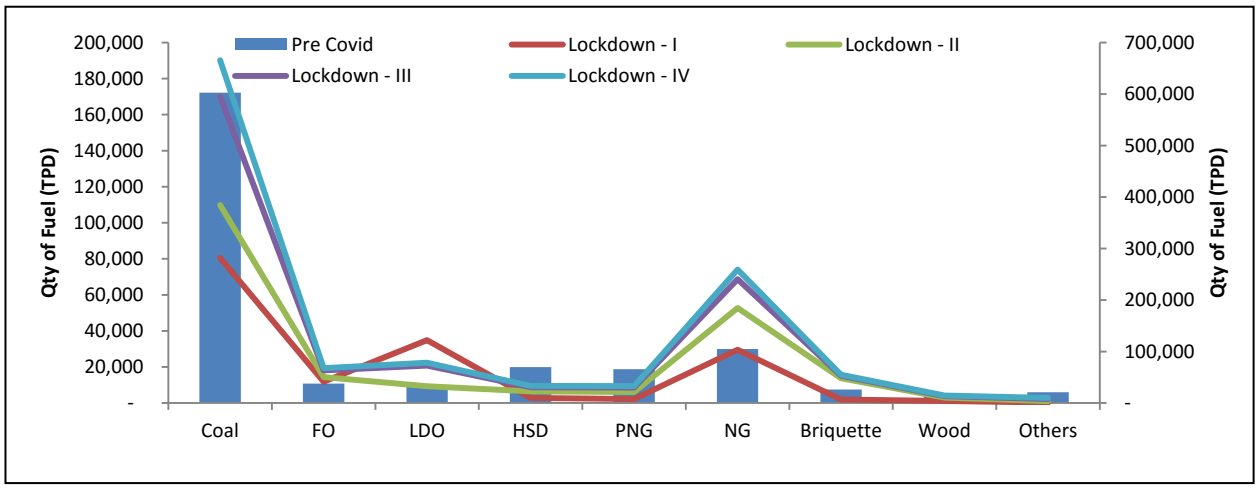


Figure 5 Fuel consumption pattern in industries in Maharashtra during various lockdown phases

It is extremely interesting to note that the impact of Lockdown has percolated to a great extent in terms of use of fuel as most of the industries have been either shut down or not permitted to be operational. Even if all the 9,000 odd industries that were allowed to operate during various phases of the lockdown imposed by Maharashtra Government, it is evidently clear that the total fuel consumption has drastically reduced and that would as it is translate

into emissions reductions. The % change in fuel consumption pattern over the study timeline is presented in **Figure 6.**

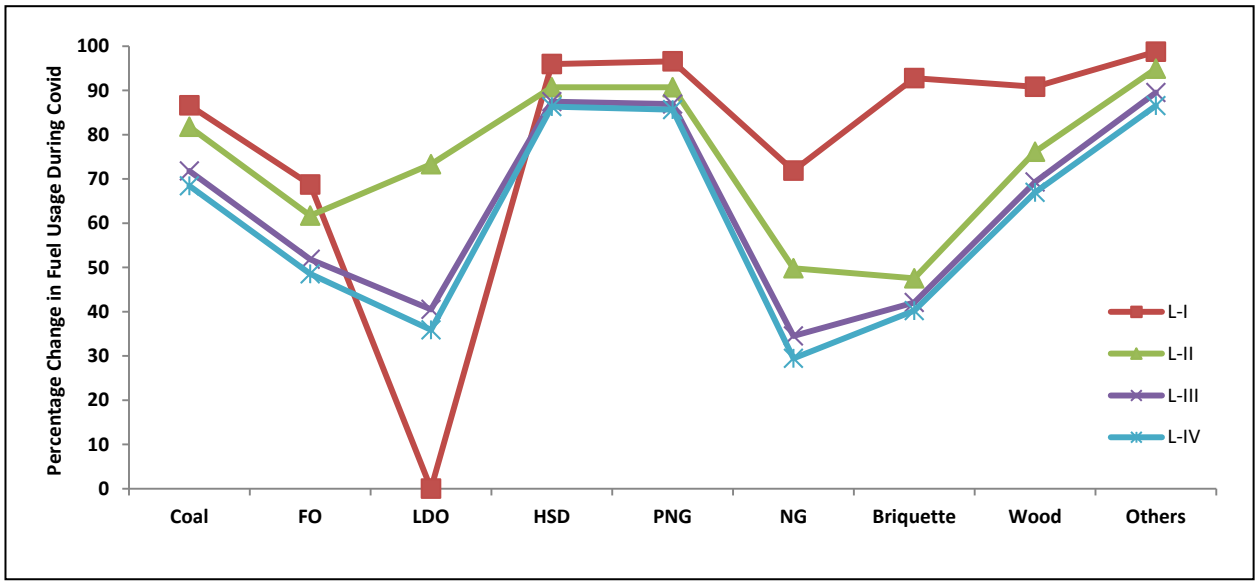


Figure 6 % change in fuel consumption pattern in industries during lockdown

The uneven changes in distribution pattern over study period of fuel is variedly marked from **Figure 6,** wherein considering pre- COVID-19 as 100% of the total value, Natural Gas & FO were used to maximum extent during L-I (about 30%) whereas by end of L-IV, Coal & Wood (32%), LDO & Briquettes (about 60%) & NG (71%) were utilized by the industries that were permitted. All other remaining fuels are all the most reduced fuel with almost 80-85% reduction in their consumption as found up to L-IV phase. One of the major reasons for such reductions probably is that most of large scale industries such as sugar & Distillery, API, Food & other almost 50 category as per MPCB classification on online portal were permitted during various periods of lockdown & thereby the skewed representation of fuel patterns is observed.

5.1.1.1.1 Impact on Air Emissions Load from Industries

Fuel consumption is supposed to be one of the major contributors of point source emissions which is evidently represented in **Figure 7.**

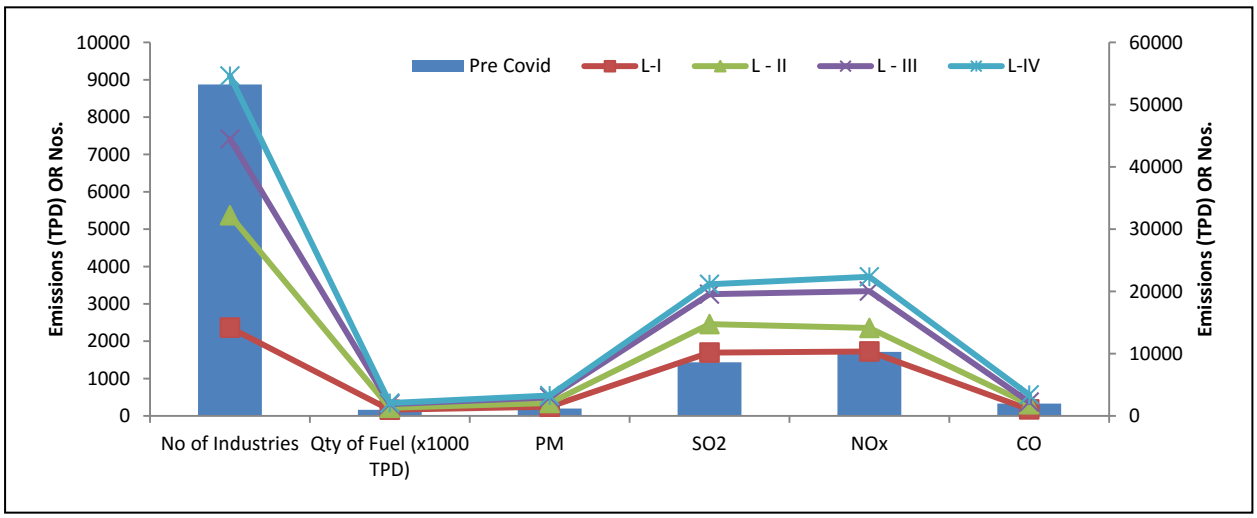


Figure 7 Impact on pollutant Emissions due to industrial fuel during lockdown

With almost only 18-20% of the industries allowed till the unlock 1.0, it is to be noted that the equivalent amount of fuel quantities too shall be reduced which in terms translates into pollutant reductions (though not equivalent). Considering pre- COVID-19 period as 100% of the value of the operations / permissions granted to the industries through MPCB, it is observed that only 4% of industries were permitted during L-I whereas 10, 14 & 17% of the industries finally were allowed to be operational classifying as essential services as permitted by the various circulars of Maharashtra Government. This in turn translated into reductions to the tune of about 14% for HSD, PNG & Other fuels whereas 30-40% for coal & wood & 50-70% FO, LDO, Briquette & Natural gas consumption by end of L-IV. The fuel consumption changes when computed for equivalent reduction in pollutants thereby reflecting 50% PM_{10}, 60% SO_2, 65% NOx & 70% CO by end of L-IV as a whole from various fuel combustion processes.

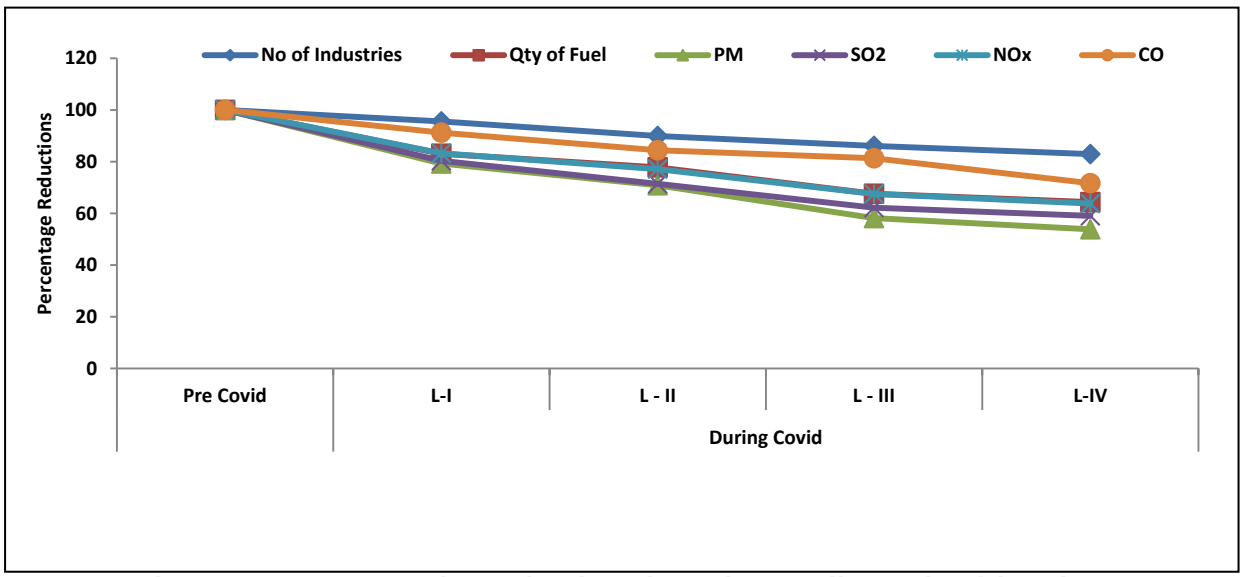


Figure 8 Stage wise reductions in various pollutant load (TPD)

Interestingly CO reduction is found to be maximum whereas PM_{10} the minimum which may be due to the release of SO_2 from combustion of coal in Thermal Power Plants & also consideration of HSD / Diesel as permitted for mostly used in DG sets (though its only the permissions and not operational real values) which were functional throughout the lockdown; almost at the same rate as during pre- COVID-19. Except that for reduction in load for industrial applications & rightly so is witnessed by the limited reductions as compared to other pollutants. Emissions factors for fuel combustion is adopted from various resources such as studies of ARAI, IITM for Common Wealth Games, Emissions Inventory of Pune (PREIS), Development of Emissions Inventory for Pune City by NEERI & other published and already validated studies. Stage wise reductions in various pollutant load (TPD) is presented in **Figure 8** for better understanding of the effect of lockdown on environment due to limited activity in industrial sector which in turn is expected to be translated into ambient air quality. Details of Emission Factors with references are cited in **Annexure I**.

5.1.1.1.1.1 Share of Emissions

It is extremely important to evaluate the share of emissions emanating from each of the fuel so as to determine strategic interventions whenever MPCB may take it up. **Figure 9** presents share of PM_{10} from different fuels based on total emissions load in TPD and changes that occur due to fuel usage during phases of lockdown along with % share.

Almost entirely, coal forms the major source for PM_{10} from industrial fuel combustion with 65% during pre- COVID-19 & gradually reducing to 44% by end of L-IV whereas FO is the 2nd largest contributor towards PM_{10} with increasing from 13% to about 40% by end of L-IV. Mix of other fuels contributes about 9% whereas all the remaining fuel contributes about only 10-12% towards PM_{10}. The trends remain similar throughout the phases with major contributor as coal & FO except for L-II where PM_{10} share from FO is highest at 44%. Impact on PM_{10} can be directly related combustion of these 3 fuel types over the entire study phases.

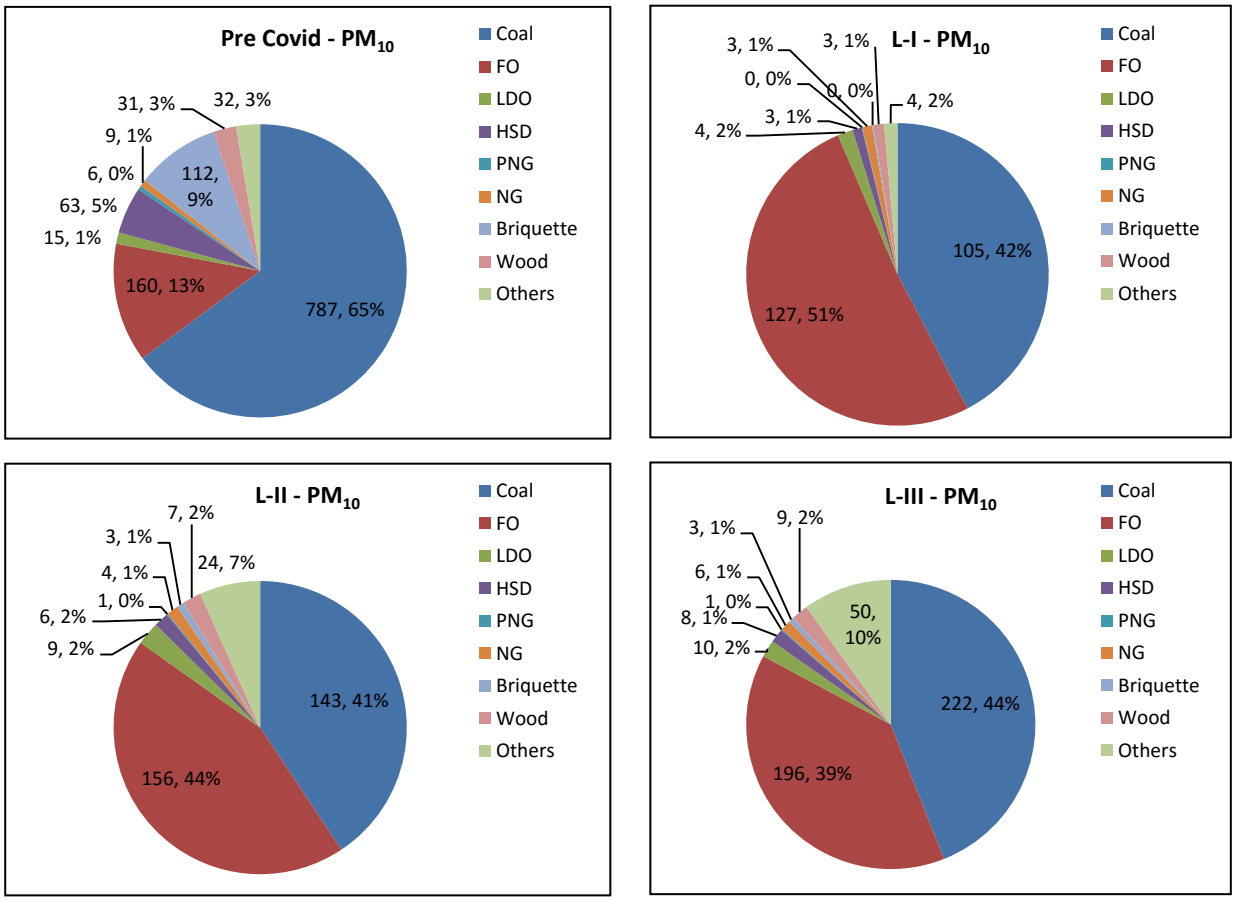
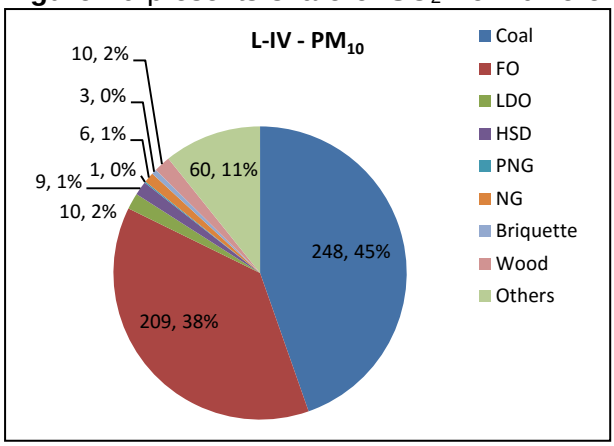
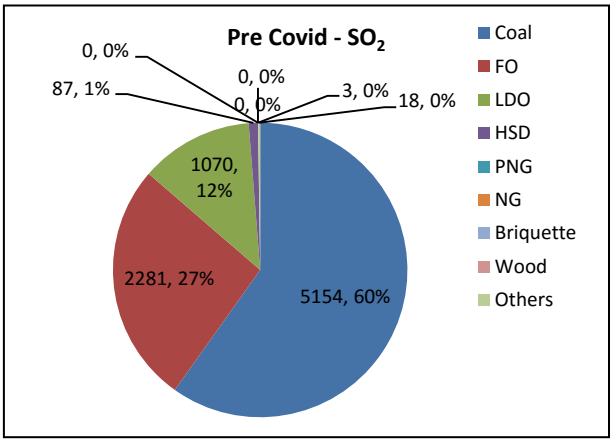
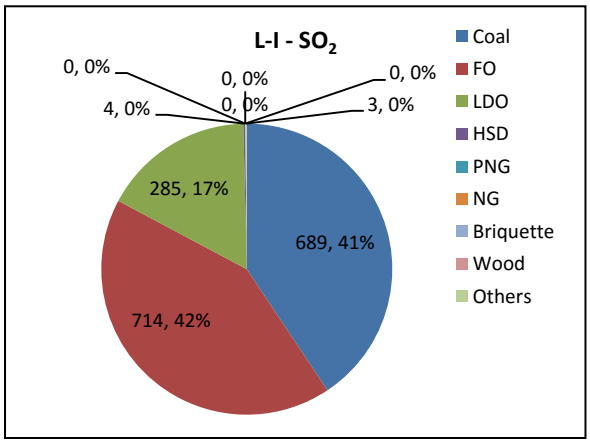


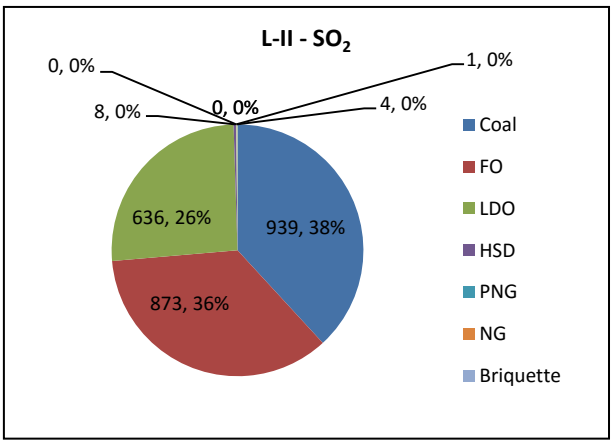
Figure 9 Share of PM_{10} from different fuels based on total emissions load in TPD during lockdown

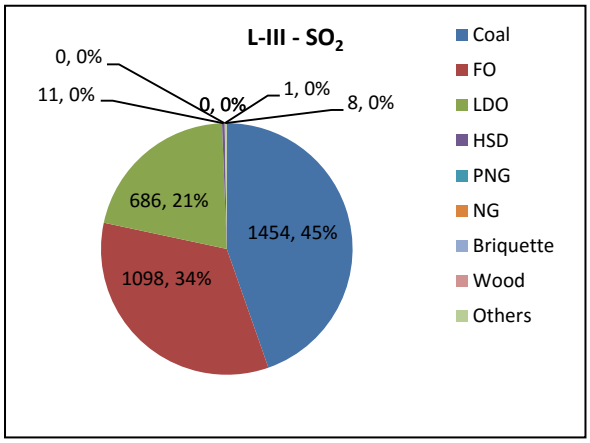
Figure 10 presents share of SO_2 from different fuels based on total emissions load in TPD and changes that occur due to fuel usage during phases of lockdown along with % share revealing that pre- COVID-19 contributions towards SO_2 is mainly from coal, FO & LDO which is obvious ranged at about 60& whereas with marginal variations this continues to be trend throughout different phases of lockdown with coal amounting for about 38-45% of SO_2 whereas FO & LDO follow the suit ranging from 35-40% and 17-25% respectively. The contribution share resembles almost that similar to those for PM_{10}.











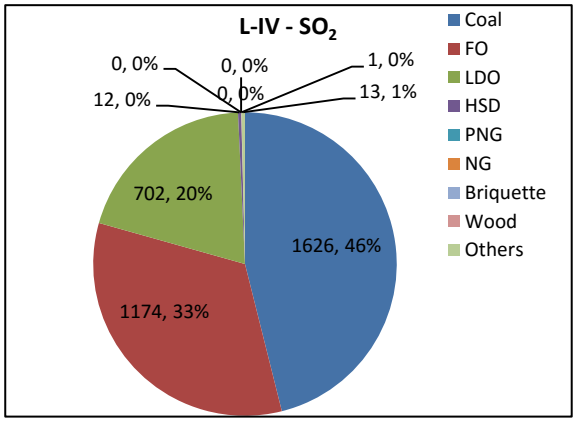
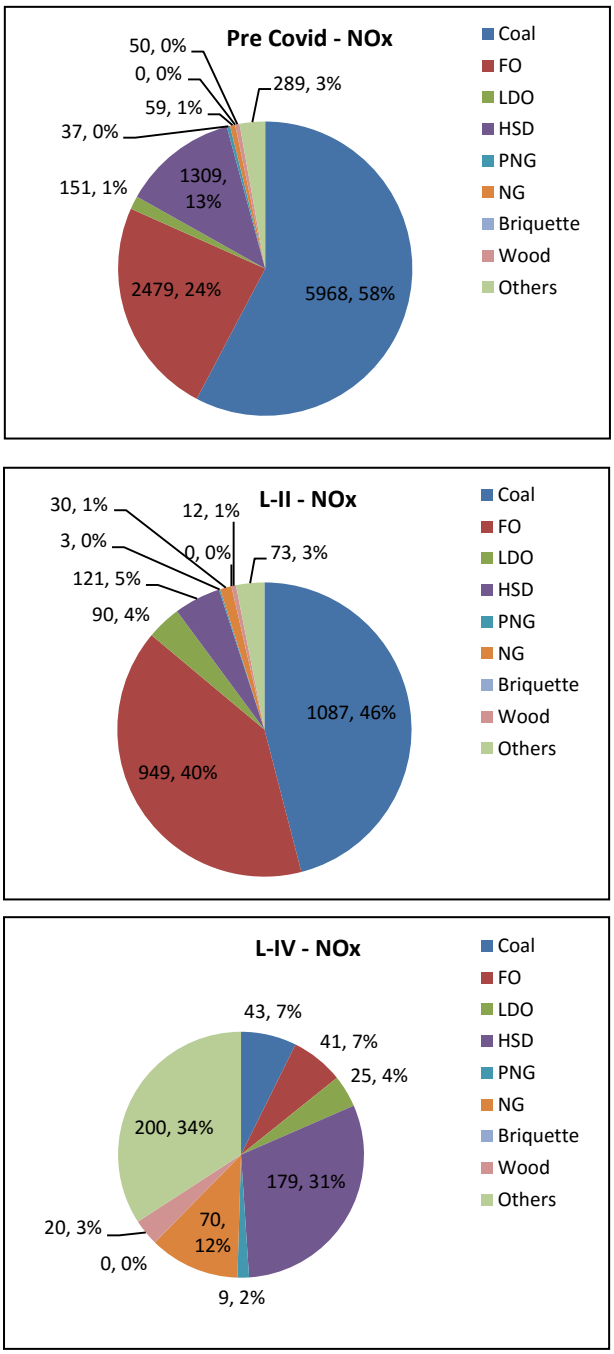


Figure 10 Share of SO_2 from different fuels based on total emissions load in TPD during lockdown



The trends seen in case of PM_{10} & SO_2 continue to be followed in NOx contributions too. However, interestingly, HSD starts to show its contributory impact during Pre- COVID-19 itself instead of LDO as in case of earlier pollutants contributor

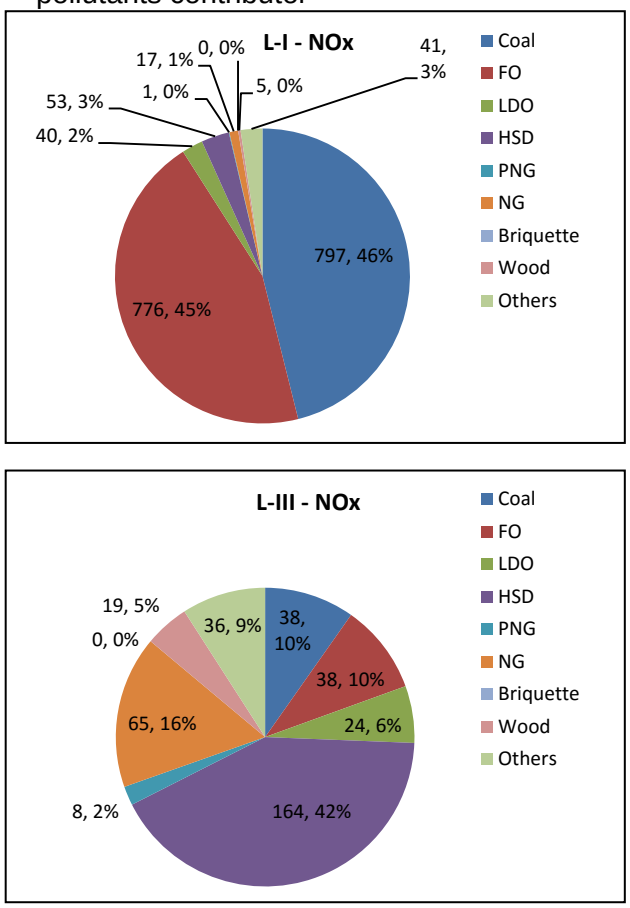


Figure 11 Share of NOx from different fuels based on total emissions load in TPD during lockdown

towards emissions load from **Figure 11.** Also that the Other fuels that include bagasse & LPG shows its impacts from L-III with finally 34% contributions towards NOx emissions load by end of L-IV. Natural gas too forms one of the considerable contributors during L-III & L-IV with about 12-16% share.

Finally, distribution share of CO emissions load when considered, HSD with 64% contribution seems to hold major fraction during Pre-COVID-19 followed by that of others whereas all the remaining fuels contribute almost equally. During L-I however, almost all fuels contribute equally with little higher contributions from HSD & LDO & by the end of L-IV Natural gas contributions increase gradually to about 16% along with HSD @ 42% & whereas Coal, others & FO contribute to about 10% each.

5.1.1.2 Thermal Power Plants [TPP]

Assumptions

Based on a data on Wikipedia from MAHADISCOM, the distribution of energy transfer is taken as;
Residential – 72.4%
Agriculture – 16%
Commercial – 7%
Industrial – 2.80%

- In lockdown 1, 100% residential & marginal industrial consumption of 0.4% total being 72.8% of energy is consumed
- In lockdown 2, 100% residential with 20% agricultural activities, & 30% industrial activities
- In lockdown 3, 100% residential with 50% agricultural, 50% industrial and 50% commercial
- In lockdown 1 100% residential, 75% agricultural, 75% industrial and 50% commercial
- 0.70kg/KW of Coal consumption

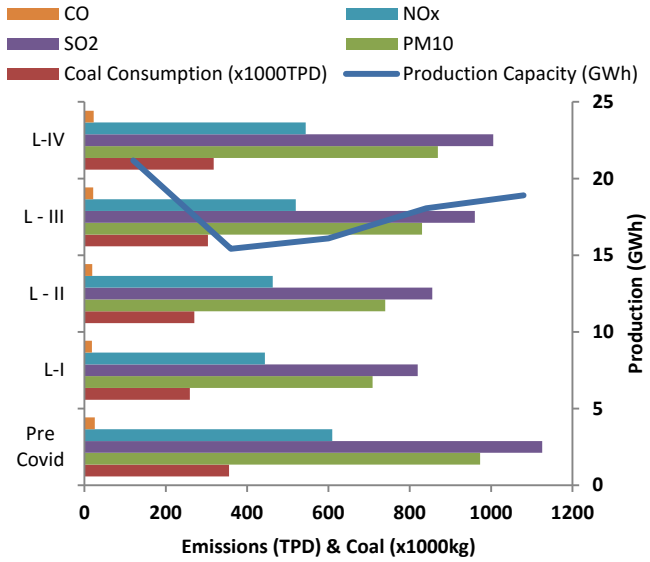


Figure 12 Emission load for pollutants from Thermal Power Plants in State during lockdown

One of the other major contributors in terms of point source emissions are the thermal power plants. Maharashtra produces about 36.7GW/d[12] of electricity and about 57% of it is generated by combustion of coal within the State. The State consumes about 3.55Lakh tons of coal every day[13]. Appropriate Emission factor as presented in **Annexure I** is selected for computation of emissions load for each of the pollutants and presented in **Figure 12**.

SO_2 is the major pollutant emitted due to direct coal combustion in TPP followed by PM_{10} which is obviously well known fact. Maharashtra State accounts for about 975TPD of PM_{10} & 1125TPD of SO_2 along with about 609TPD of NOx & meager 25TPD of CO in the normalcy state i.e. Pre-COVID-19 days. However, the impact of Coronavirus lockdown as reflected due to the assumptions stated herewith with the coal consumption reduced by 27, 24, 14.7 & 10.7% respectively during L-I, L-II, L-III & L-IV, there would be an anticipated equivalent reductions in pollutants to the same tune / amount.

5.1.1.3 Transportation Activity

With lockdown being imposed by Indian government in various phases anticipating impact of pandemic creating huge potential crisis in Indian scenario based on various reports of predictions on the exponential rise projected in India, life was brought to a standstill for the betterment of people's health & wellbeing at the very onset of Coronavirus. Furthermore, the known awareness and scare amongst general public of the community spread, mobility was hugely; in fact completely brought to a halt with only the extremely essential transport vehicles allowed during the first phase & certain relaxations being given during subsequent stages of lockdown.

[12] MAHAGENCO, MEDA, Central Electricity Authority, GoI, Tata Power Co. Ltd, Reliance Infrastructure / Adani Electricity, Economic Survey of Maharashtra, 2019 - 2020
[13] Performance Review of Thermal Power Stations 2006-07 Section-9

It is known that vehicles or the Line sources contribute to almost 18-30% of PM_{10} as direct release whereas 40-50% from allied impacts of re-suspension of dust in urban areas. Not only that, vehicle movement & fuel combustion also is known to be responsible for about 45-60% of the gaseous emissions load in terms of inventory as published by various reports in the past[14] in urban scenarios with marginal industrial activity.

Assumptions for Computing Resuspended Dust (PM_{10})

- VKT calculated previously is distributed onto Rural & Urban roads
- Paved & Unpaved road is calculated using Ministry of Road Transportation & Highway that provides surfaced & Not surfaced kms of road in Maharashtra
- Surfaced (Paved) = 495362KMs, Not Surfaced (Unpaved) = 128610KMs. Paved % = 79.39 & Unpaved % = 20.61
- Using the same COVID-19 Period Google Mobility data, VKT is distributed on to paved & unpaved roads
- EF from PREIS study of Pune is used for computing emissions load

Assumptions during Covid Period

Distribution of vehicles during phase of lockdown adopted using Google Mobility data. (https://www.gstatic.com/COVID-19/mobility/2020-06-06_IN_Mobility_Report_en-GB.pdf)

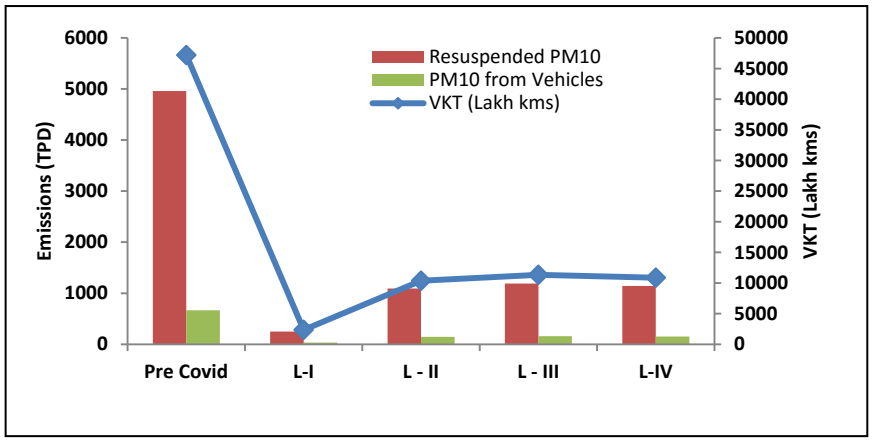
- Google provides daily vehicular activity in form of reductions compared to baseline since adopted since March 1st for this study
- For L-I, only 5% vehicles in essential transport sector such as Ambulance, police vehicles private buses and cars with permit was allowed.
- For L-II, 22% vehicles in the state of Maharashtra was allowed consisting of emergency services, essential goods & permit holding traveler.
- For L-III, 24% vehicles in the state of Maharashtra was allowed consist of emergency services, essential goods, local movement within district in green and orange zones
- For L-IV, According to Google mobility data 23% vehicles in the state of Maharashtra was allowed consist of emergency services, essential goods, local movement within district in green & orange & red zones including inter-district & interstate transport except for the restricted movement in containment zones

Taking cue from the restricted mobility scenario in the state of Maharashtra, attempt has been made to understand the dynamics of the mobility patterns along with impact of emissions from vehicular sector in terms of direct tail pipe emissions & indirect re-suspended dust emissions during various phases of Lockdown.

Assumptions for Pre-COVID-19 Period

- Category wise vehicle data is obtained from Maharashtra Governments Transportation Portal as on 31st Jan 2017
- Appropriate Annual Growth rate is applied for each category of vehicles to forecast 2020 vehicle population
- Vehicles are distributed into 5 categories i.e. 2W, 3W, PV, LCV, HCV
- Average distance travelled (ADT) by each category of vehicles is adopted from Research Article in Atmospheric Environment Journal published in 2009 & 2010 Delhi CWG Survey (MoES)
- Various ADT's used are
  - HCV's – 100000kms/A i.e. 200km/d
  - 2W – 6300kms/A i.e. 120km/d
  - 3W - – 12600kms/A i.e. 150km/d
  - 4W – 12600kms/A i.e. 80km/d
  - LMV – 33500kms/A i.e. 100km/d
- Emission factors are adopted form ARAI 2007 report to convert VKT calculated from ADT & vehicle numbers

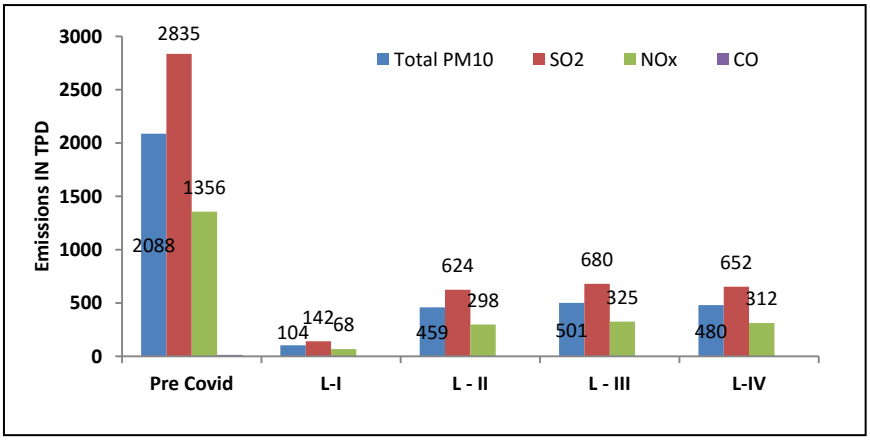
[14] Six cities repots, Give ref of NEERI AQM Pune Study – USEPA, Mumbai – PMRAP, ARAI report of Pune, CPCB studies of Source inventory, etc



It is estimated that the total number of vehicles in Maharashtra with a population of 11.23cr as per 2011 Census & projected to be around 12.49cr for 2020 is estimated to be around 39,880,151[15].

Figure 13 vehicle wise VKT & its share on paved v/s unpaved roads in terms of emissions of PM_{10}

Considering the worst case scenario, an estimate of the total vehicle kms traveled by all the vehicles when on road as per the ADT assumptions[16] seems to be around 472cr kms. The estimated distribution of vehicle wise VKT & its share on paved v/s unpaved roads in terms of emissions of PM_{10} is presented in **Figure 13.** By end of L-IV phase, it is estimated that a total of 108cr kms of VKT / day is part of the daily routine of transport in the State with about 5 - 8 times additional share of resuspended dust contributed due to vehicle movement every day amounting to be about 1150TPD by end of L-IV whereas vehicles contribute about 667TPD of PM_{10} during the pre- COVID-19 period along with 5000TPD of resuspended dust.



Emissions of SO_2 seem to be the highest obviously due to the high VKT & EF from HDDV (Heavy Duty Diesel Vehicles). Yet the share of total PM_{10} emissions is around 667TPD during pre-COVID-19 which due to the extreme restrictions posed by government of the day is reduced drastically to just about 33TPD during L-I gradually increasing to about 150TPD by L-IV. Similarly, share of SO_2 load too amounts to about 900TPD & that of NOx to about 820TPD by end of L-IV as against 3900 & 3500TPD respectively. CO on the other hand shows highest contribution through vehicular sources amounting about 7000TPD & 1600TPD during pre-COVID-19 & L-IV periods of study respectively.

[15] According to Unique Identification Aadhar India, updated Jan 2020
[16] T.V. Ramachandra & Shwetmala, Emissions from India's transport sector: Statewise synthesis, Atmospheric Environment, 2009, pg-1-8 & Estimates from PREIS, Pune Emissions Inventory Study, 205-14

5.1.1.4 Impact on Area Sources

Essentially, it was also thought to evaluate area sources which usually form considerable contribution to the overall ambient air quality. Though the data is limited to some surveys being conducted in previous Emissions Inventory studies of especially those conducted by USEPA, NEERI & PMC attempt has been made to use it to the best possible approach for most scientific and validated method of acceptability. The baseline survey for almost all sectors / activities are from in and around Pune and may be thought to represent both rural and urban scenarios of Maharashtra as the case has been adopted along with its comparison with some available ground data from Delhi-NCR collated during primary surveys in this region including rural settings for all indicators / surrogates leading to activity definitions for emissions calculations. Construction, hotels & bakeries, have been studied as area source contributors to understand their share towards the total emissions load and the possibility of it translating into ambient air quality concentrations.

Assumptions for Hotels

- There are 1,05,000 hotels in Maharashtra in Dec 2016
- Hotel numbers vary from year to year with reduction of 12,000 units since 2015
- Thereby, considering average 1,00,000 hotels as on March 2020
- 30% big consuming 7 & 70% small consuming 1 LPG cylinders / day
- Fuel use data is derived from PREIS & validated in 2014 EI-Pune studies
- During Covid, No hotels / restaurants in L-I, 20% in L-II only for food delivery, 30% in L-III & 50% in L-IV

Assumptions for Bakeries

- Estimated 44,769 bakeries based on data from Argon Food Processing
- 20% small & unorganized using firewood averaging 33kg/hr with 24hr working as estimated from primary survey in PREIS & validated in 2014 EI-Pune studies
- Diesel operated bakeries are not considered
- Large bakeries use multiple and cleaner fuel thereby using average of 33kg firewood for all bakeries
- Being essential, 20, 40, 60 & 75% operation in L-I, L-II, L-III & L-IV Phases respectively

Assumptions for Street Vendors

Street Vendors

- Data gathered from National Association of Street Vendors, 50th Round of NSSO (1993-94)
- Urban area – 0.89% of population whereas Rural area – 0.27%
- Projections based on 5cr Urban & 6.15cr Rural population of State
- Fuel consumption data adopted form PREIS & validated in 2014 EI-Pune studies
- Fractions using Coal, Kerosene, LPG & Wood = 5.3, 31.6, 43.4 & 25.0 resp
- Qty of fuel per day = 3.62, 0.17 & 8.37kgs of kerosene, LPG & wood resp.
- Phase L-I, L-II & L-III have had strict restrictions on the street vendors thereby no such emission reflected whereas L-IV assumes to have only 10% scattered vendors operational

Construction too being one of the identified and most deliberated sectors is thought to account for considerable PM_{10} emissions that is attempted to be computed using surrogate data from various references.

Tourism industry is the most impacted sector due to COVID-19 pandemic and so if reflected by the lockdown protocols which still restricts restaurants & hotels from operating in certain zones. Similarly, street vendors are the most vulnerable from not only economic point of view but also from their effective exposure potential and rightly so the government restricted all the hawkers and street vendors thereby effective several of the area source emissions directly. On the other hand, bakeries being classified as essential supply of food material had been surely operational during almost the entire period especially the larger brand ones.

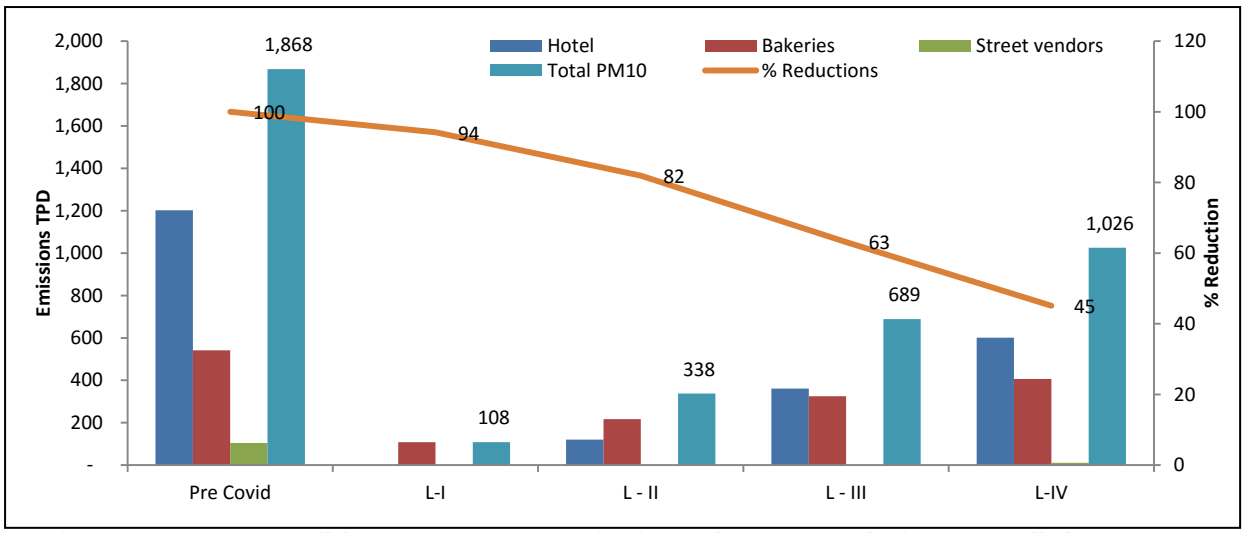


Figure 14 Overall impact of PM_{10} emissions due to restrictions on all the area sources

With the stated assumptions & limitations of primary data it may not be completely possible to imitate the exact contribution yet an attempt is made to evaluate the overall impact of PM_{10} emissions due to restrictions on all the area sources represented in **Figure 14**. It is estimated about 1500tons/day of firewood be used by bakeries across Maharashtra generating about 541TPD of PM_{10} whereas hotels leading to about 1,200TPD & street vendors using 700KLD of kerosene, 45,000l/d of LPG & 404TPD of wood potentially generating only 100TPD of PM_{10}. With a share of 64%, Hotels form one of the major sources whereas bakeries & street vendors contribute 29 & 6% each towards the total PM_{10} emissions load. The lockdown however witnesses 98% reduction in L-I followed by 82, 63 & 45% reductions in PM_{10} load across L-II, L-III & L-IV respectively.

In terms of gases, SO_2 & NOx emission loads are to be also considered amounting to 242TPD & 1082TPD during pre- COVID-19 period & subsequently reduced during various phases of lockdown finally adding about 116TPD & 550TPD by end of L-IV respectively. However, it is interesting to note that there is substantial CO emissions to the tune of 4,500TPD (with almost 95% from bakeries) may be mostly due to unregulated & inefficient burning as represented by high EF used for estimation purposes. Emissions during lockdown are considerable with bakeries functional to great extent reaching finally to 3200TPD by end of L-IV.

Maharashtra accounts for nearly 25% of the total investments attracted by real estate & construction in India[17] of Rs. 14.5Lakh crore industries possibly translating into Rs. 3.65Lakh Crore / annum for Maharashtra in Construction sector industry.

- Assuming average cost of construction to be around Rs. 1350, the total area of construction amounts to be 67000acres/annum
- About 6000acres/month
- Phase L-I had complete restrictions on any construction whereas L-II is assumed to have initiated about only 5% of construction activities followed by 15% in L-III & 40% in L-IV
- These assumptions are conservative considering that construction labours may have migrated and even with the permissions granted, actual construction may be extremely limited

Emission from construction is extremely marginal with only 21TPD during Pre- COVID-19 whereas L-IV showing 8TPD with limited activity due to resource constraints.

[17] ASSOCHAM – The Associated Chamber of Commerce & Industry of India, 10th May 2017, PTI

5.1.1.5 Sectoral Sources Impact on Air Emissions in Maharashtra

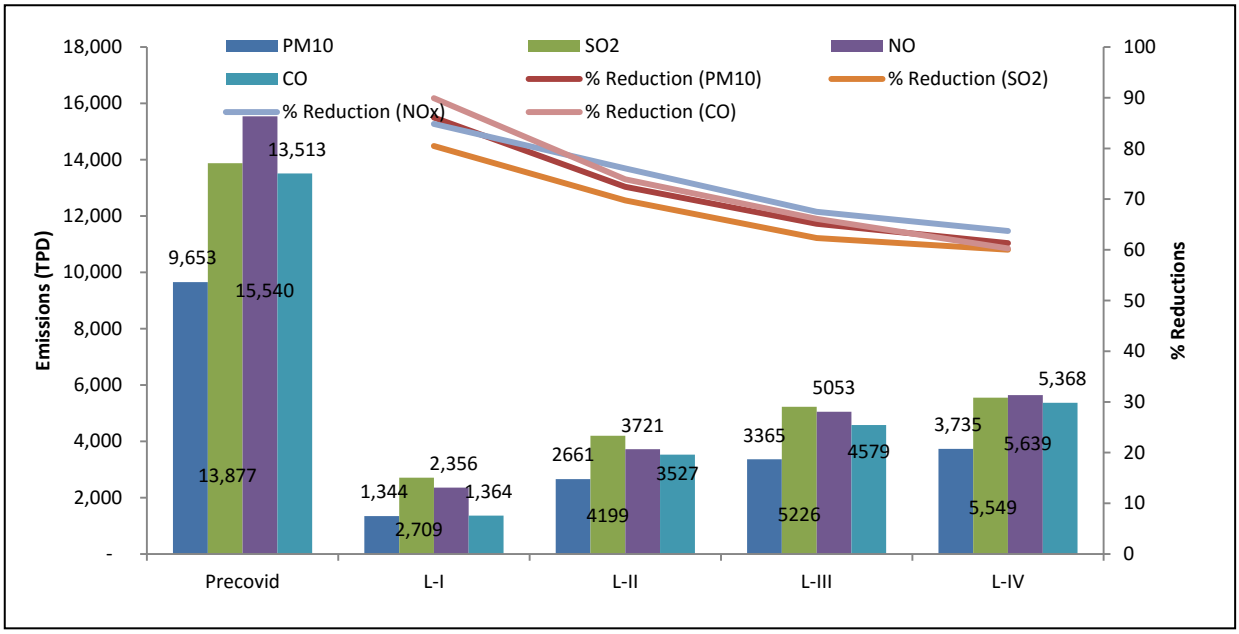


Figure 15 Overall changes in emissions with % reductions during lockdown phases

These phases of COVID-19 pandemic is done, an evaluation of the overall changes in emissions with % reductions over these various phases of lockdown vis a vis Pre-COVID-19 period is depicted in **Figure 15** with the total emissions from all relevant studied sources clubbed together. Even though the trends in reduction show similar trends the absolute impact on pollutant emissions is different especially in light of the varying activity as well as emission factor values. PM_{10} & CO shows the maximum reductions during L-I phase probably due to the extremely limited transportation as well as fuel used in industries, which is further evaluated in subsequent discussions depicting share of each sector towards emission load reduction across phases.

On the other hand it also shows increased emissions by end of L-IV though the CO emissions do not increase in exact relative equivalent terms. NOx emissions are the least by the end of L-IV whereas SO_2 increase remains gradual throughout various phases mostly due to the thermal power plant operations that did not changed much during the study period.

5.1.1.5.1 Sectoral Share of Sources towards PM_{10} Emissions Load

When % share of various emission sources for PM_{10} as depicted in **Figure 16** is discussed, it is revealed that during Pre-COVID-19 period, maximum share from Re-suspended dust out of the total of 10,000TPD emissions in Maharashtra State and about 52% of the share is contributed by Re-suspended dust. Industries & area sources (including Hotels, Bakeries & Street vendors) totally contribute 32% (about 8% each) whereas Thermal Power Plant's (TPP) share towards PM_{10} emissions load is 11%. If TPP are considered as industrial emission point source, the total contributions amount to about 24% whereas vehicles in terms of PM_{10} emissions share seem to be only about 7% & negligible emissions from construction sector.

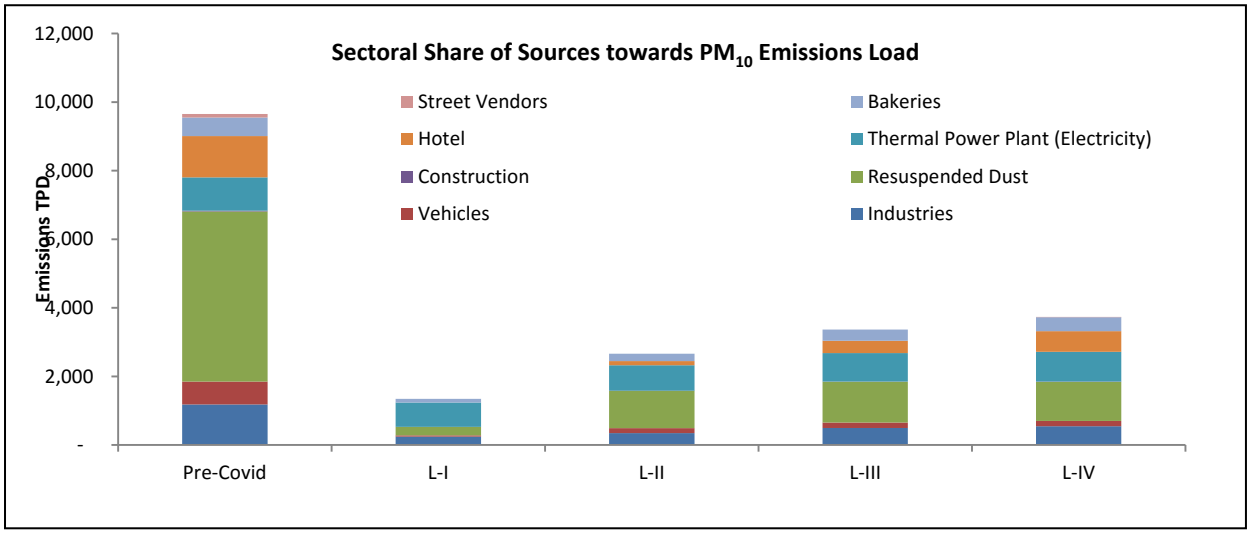


Figure 16 Sectoral share of sources towards PM_{10} Emission Load contribution

During the COVID-19 phases, Thermal Power Plant (TPP) accounts for 50% share that subsequently reduces to about only 11% by end of L-IV since all the other activities take over emissions load share over the time. Re-suspended dust shows reduced share from 51% to about 30%. Industries with its limited essential manufacturing still contributed a share of about 18% during L-I. Sectoral share of source contributions is presented in **Figure 17**.

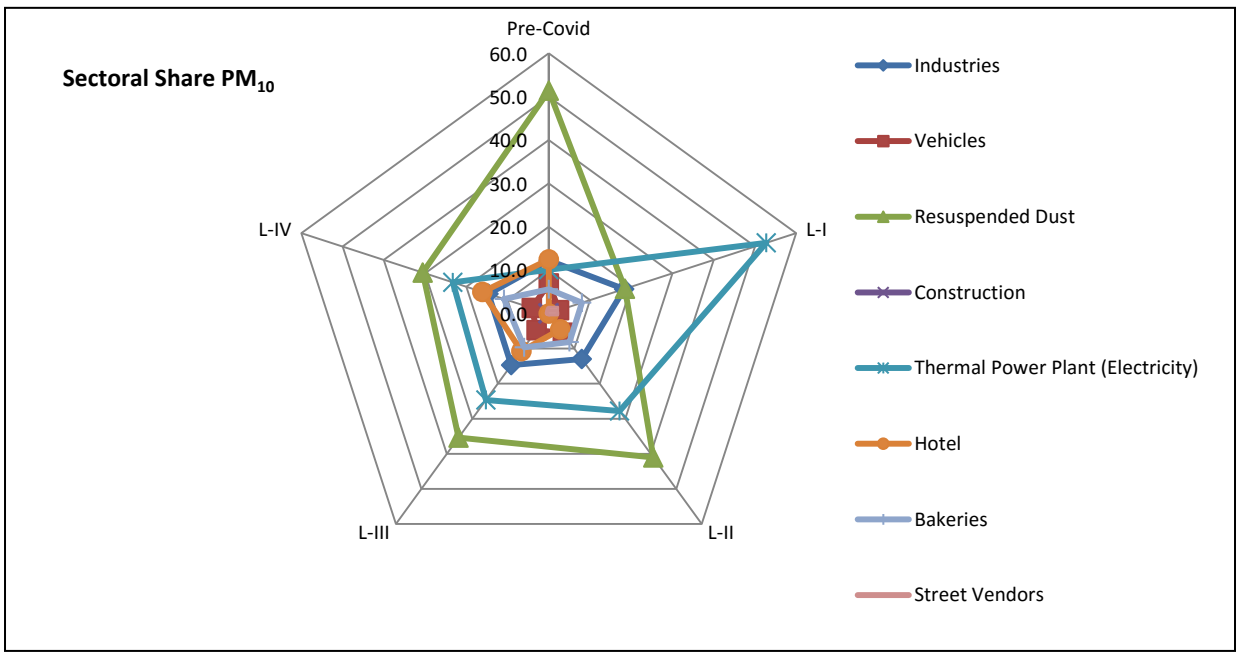


Figure 17 Sectoral % share contribution across all sources of sources towards PM_{10}

5.1.1.5.2 Sectoral Share of Sources towards SO_2 Emissions Load

The source contributions towards SO_2 during Pre-COVID-19 period (i.e. to the tune of about 13,877TPD) is limited to only Thermal Power Plant with 9% share, vehicles with 30% and industries accounting for about 63% as represented in **Figure 18**.

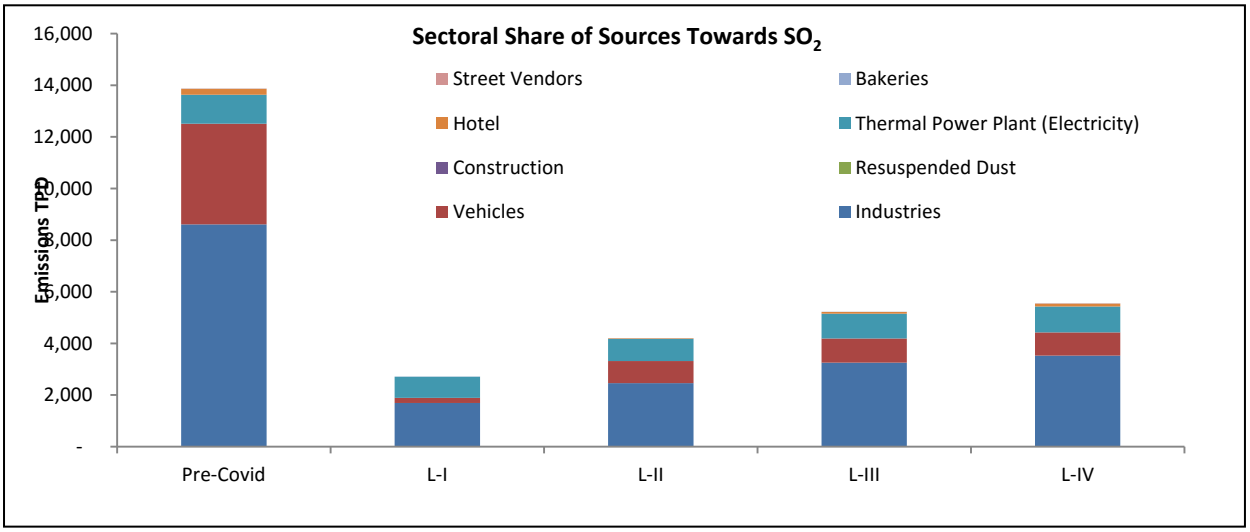


Figure 18 Sectoral share of sources towards SO_2 Emission Load

On the other hand, industries continue to share almost similar % contributions across all phases (about 60%) whereas vehicle contribution increases from 7% during L-I to 16% by end of L-IV similar to that of TPP with contributory share increasing from 8% to 18% by end of L-IV. In fact >97% of the share of SO_2 is directly contributed by these 3 sources through the phases of lockdown as presented in **Figure 19**.

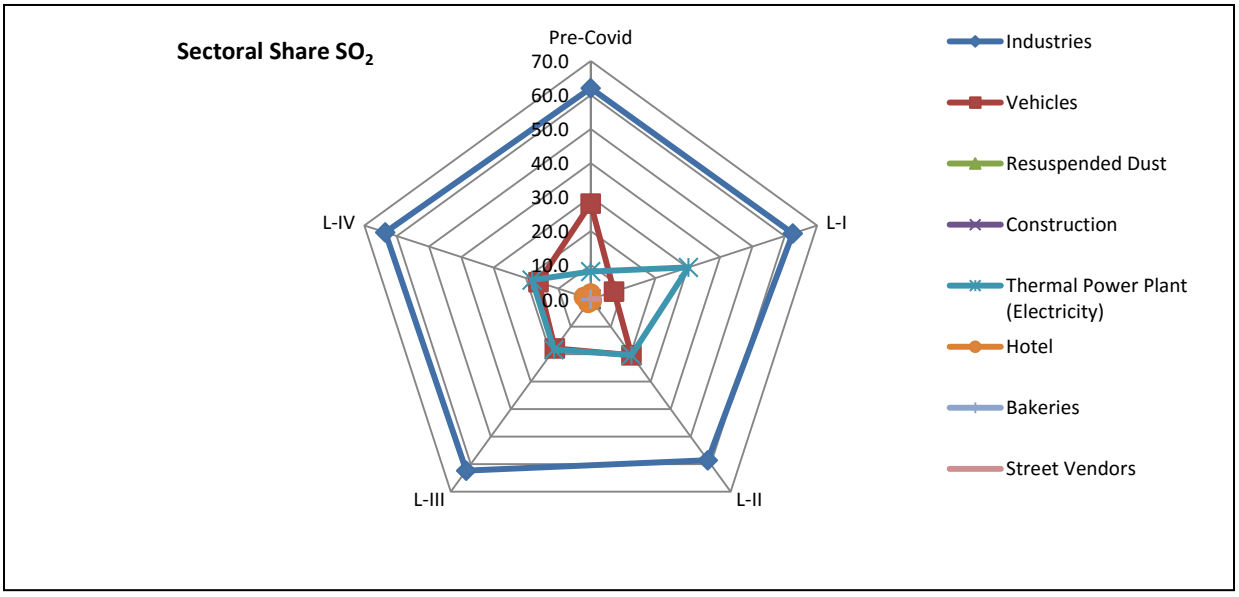


Figure 19 Sectoral % share contribution across all sources of sources towards SO_2

5.1.1.5.3 Sectoral Share of Sources towards NOx Emissions Load

In terms of NOx however, the trends suggests entirely different contributory share from sources though the trends in share still resemble that of SO_2 with industries & vehicles sharing about 66% & 22% amounting to about 89% whereas interestingly, area sources too accounts for about 7% forming 3rd significant contributor which was not seen case of either of the PM_{10} or SO_2 loads during Pre- COVID-19 period (of the total 15,540TPD). Thermal power plant shares only 4th rank with 3.9% during this phase as represented in **Figure 20**.

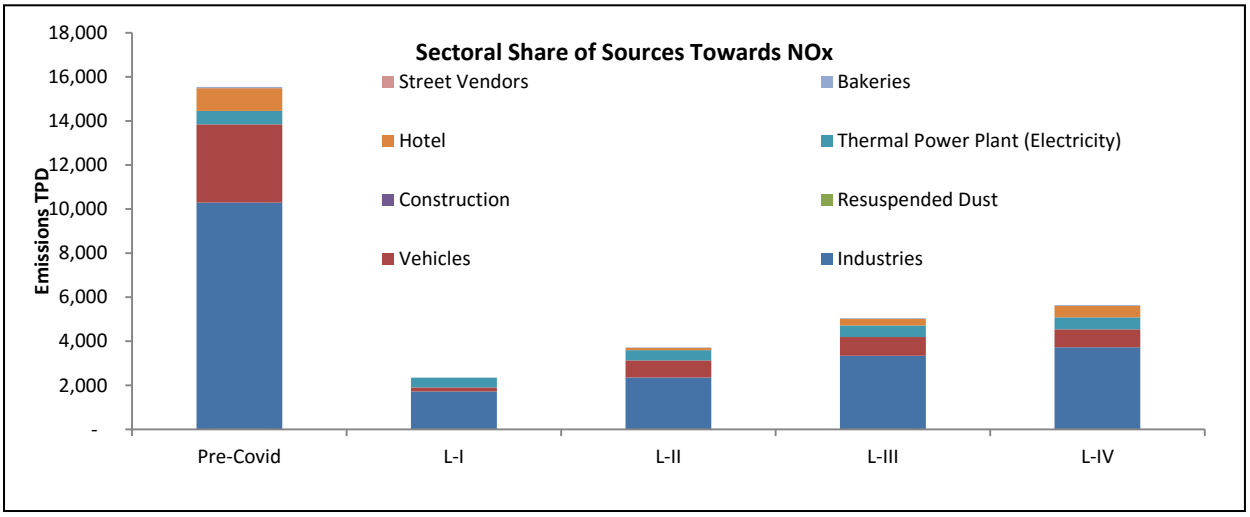


Figure 20 Sectoral share of sources towards NOx Emission Load

Share of industries during L-I is the highest across the phases of lockdown with about 71% share which by end of L-IV reaches similar to that of Pre-COVID-19 at 66%. Vehicles however show interesting trends with L-II having maximum share within the lockdown period (about 21%) through less that Pre-COVID-19 obviously. TPP's contribution by end of L-IV shows significant rise to the extent of 9.6% along with that from area sources with a share of 9% too by the end of L-IV. In fact if TPP is considered as industrial point source, >70% of the share of NOx is directly contributed by it as depicted in **Figure 21**.

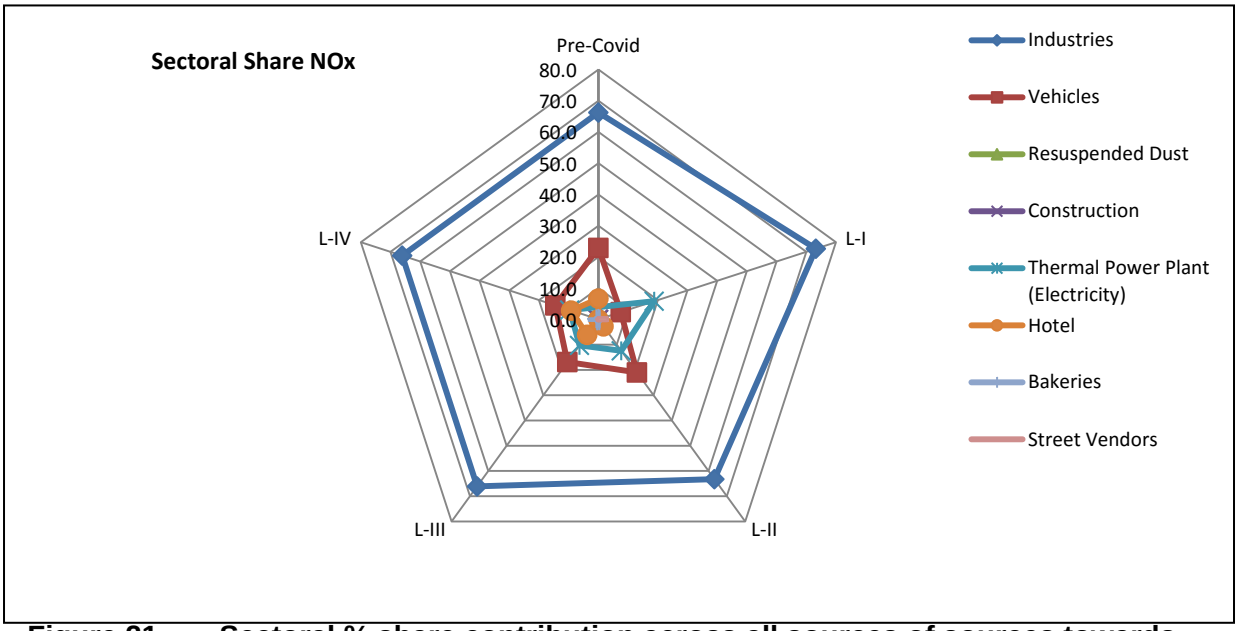


Figure 21 Sectoral % share contribution across all sources of sources towards NOx

5.1.1.5.4 Sectoral Share of Sources towards CO Emissions Load

Grippingly, area sources contribute about 30% of CO emissions load during Pre- COVID-19 period which is not the case in any of the earlier discussed pollutants. Similarly vehicles contribute a share of about 45.18% during this phase as compared to 15% from vehicles. TPP's contribute only to a marginal 0.2% which otherwise in all other pollutants cases is significantly low. The trends continue to suggest entirely different share from sources with area, vehicles & industries contributing to about 97% share of the emissions load of CO during Pre- COVID-19 period of the total 13,513TPD) as represented in **Figure 22**.

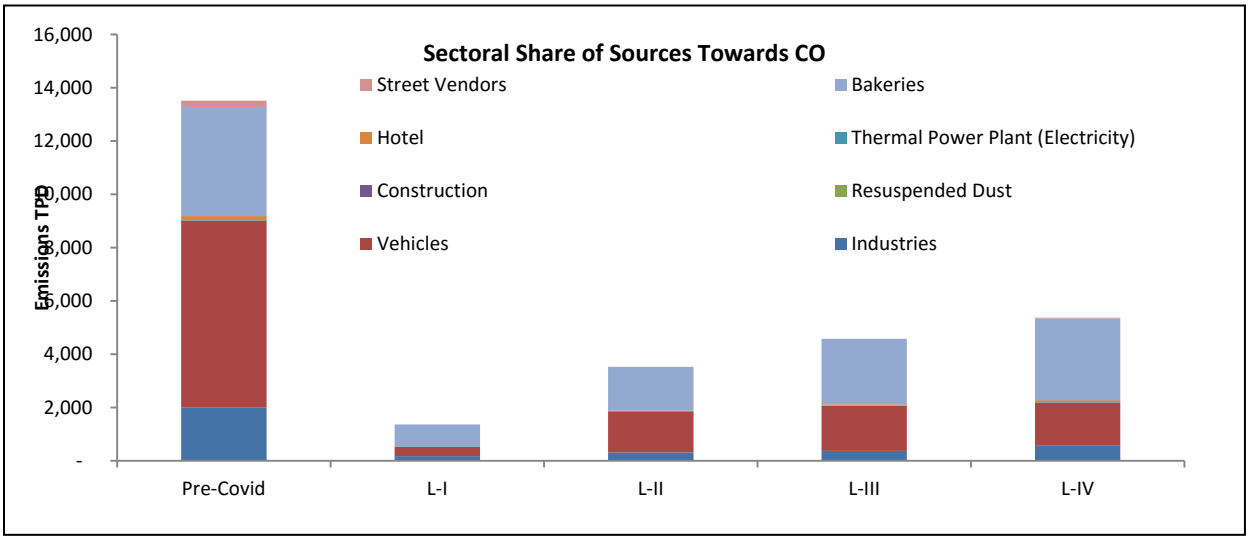


Figure 22 Sectoral share of sources towards CO Emission Load

Abiding to the pre-COVID-19 period share, the area sources are the major contributor during L-I with area sources forming almost 60% of the contribution followed by vehicles at 25% & industries @ 13% during L-I whereas the share of industries reduces to 10.5%, vehicles to 30% by end of L-IV. On the other hand, share of area sources by end of this phase L-IV itself reaches about 58%. TPP's & all other sources other than those mentioned above contribute only about 0.5% of the CO emissions load as presented in **Figure 23**.

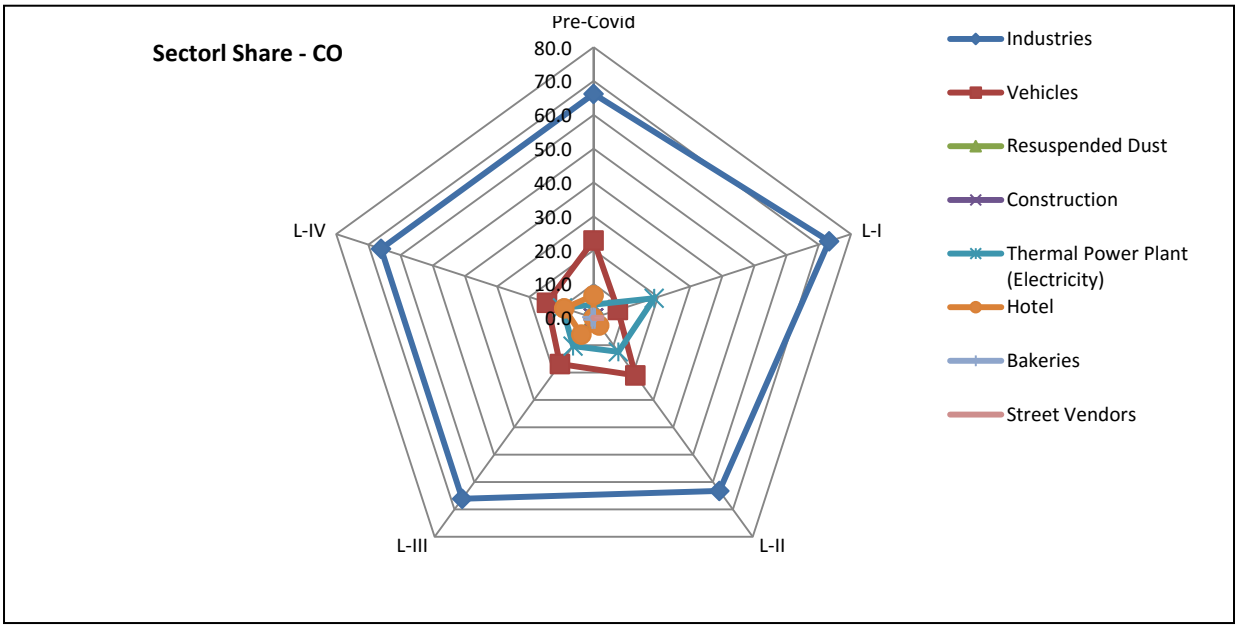


Figure 23 Sectoral % share contribution across all sources of sources towards CO

Finally, it is further deliberated to understand the rendering of these emissions into ambient air quality changes that are brought during the various Lockdown phases vis a vis Pre-COVID-19 (business as usual) scenario & attempt has been made to establish correlation between emissions from various sources to the real time ambient air quality data as available at 22 different locations monitored by MPCB using AAQMS.

5.1.2 Impact of COVID-19 on Ambient Air Environment

As a result of the strict restrictions on travelling & closure of non-essential activities including various industries, air quality improvement has been anticipated in most towns & cities across the State. Emissions load from almost all sectors contributing towards ambient air

pollution i.e. transport, industries, power plants, construction activities, biomass and refuse burning, road dust re-suspension, residential, operations of DG sets, restaurants, landfill fires, etc. have been already stated in earlier section.

As per MPCB's annual monitoring schedule 104 samples at each of the locations monitored from 72 active AAQMS is available. However, analysis of COVID-19 event on ambient air, it is most appropriate to consider data form only the Online AAQMS on daily basis & correlate with the event happenings across State.

Furthermore, air quality data generated from these stations are converted into Air Quality Index (AQI) for prominent pollutants such as PM_{10}, NO_x and SO_2 in entire lockdown phases showing gradual change as & when permissions for additional activities were granted. The comparative lockdown phases considered are as below;

- Before COVID-19 - (01.03.2020 to 20.03.2020)
- Lockdown-1 - (21.03.2020 to 14.04.2020)
- Lockdown-2 - (15.04.2020 to 03.05.2020)
- Lockdown-3 - (04.05.2020 to 16.05.2020)
- Lockdown-4 - (17.05.2020 to 01.06.2020)

Table 5 represents comparative Air Quality Index (AQI), for data collected from 22 AAQMS across state during these five phases.

Table 5 Comparative Statement of Average Air Quality Index of Continuous Ambient Air Quality Monitoring Stations in Maharashtra

Monitoring Stations	Pre-lockdown	Lockdown	% difference in AQI for Pre & post lockdown period (%)
	01-03-2020 to 20-03-2020	21-03-2020 to 01-06-2020	
More Chowk Waluj	85.29	52.01	39.01
Chandrapur, Chandrapur	78.06	71.81	8.00
MIDC Khutala, Chandrapur	81.82	77.36	5.45
Khadakpada, Kalyan	174.76	81.07	53.61
Bandra, Mumbai	101.67	68.96	32.16
Borivali East, Mumbai	79.56	62.88	20.95
Chhatrapati Shivaji Intl. Airport (T2), Mumbai	153.05	54.41	64.44
Colaba, Mumbai	104.24	56.00	46.27
Kurla, Mumbai	161.95	79.91	50.65
Powai, Mumbai	98.58	59.03	40.12
Sion, Mumbai	164.25	70.16	57.28
Vasai West, Mumbai	121.68	45.18	62.87
Vile Parle West, Mumbai	107.05	58.96	44.92
Worli, Mumbai	108.95	61.17	43.85
Opp GPO Civil Lines, Nagpur	77.73	59.98	22.82
Gangapur Road, Nashik	96.80	57.88	40.20
Airoli, Navi Mumbai	87.85	89.45	-1.82
Mahape, Navi Mumbai	148.95	74.84	49.75
Nerul, Navi Mumbai	148.39	97.35	34.39
Karve Road, Pune	98.75	60.97	38.25
Solapur, Solapur	110.30	63.28	42.62
Pimpleshwar Mandir, Thane	90.55	60.15	33.57

Source: https://app.cpcbccr.com/ccr/#/caaqm-dashboard-all/caaqm-landing/data

Legend for AQI category					
Good (0-50)	Satisfactory (51-100)	Moderate (101-200)	Poor (201-300)	Very Poor (301-400)	Severe (401-500)

A comparative statement for pre-lockdown & lockdown phases reflects changes in Average AQI at 22 AAQMS datasets suggesting considerable reduction in Average AQI; however at Airoli, Navi Mumbai, it is found to be slightly increased even during lockdown. The reason for the increase in pollutant concentrations at these locations may be due to higher % / density of essential service / industries.

As compared to pre-lockdown averages, the air quality has moved to satisfactory from moderate at 11 locations in Mumbai and Solapur. At Vasai, there can be seen a significant reduction in average AQI wherein it is moved to Good from Moderate Category.

Figure 24 represents trend analysis of AQI at various monitoring locations across state at onset an during COVID-19 pandemic periods a various stages such as panic migration of people after declaration of lockdown, during lockdown and further strict imposition of only essential services etc.

From the trend analysis of AQI across five phases, it can be clearly seen that during 1st phase (01.03.2020 to 20.03.2020) which is before any initial declaration of COVID-19 pandemic, the AQI values are fairly high in range of 100 to 200 however, at the end of this phase; increased AQI values upto 250 are observed which might be due to increased activity of panic migration of people. In 2nd phase (21.03.2020 to 14.04.2020) of Lockdown-1, due to strict restrictions and closing down all non-essential activities, values of AQI across all the stations are observed below 150 in Moderate range. The 3rd phase i.e. Lockdown-2 (15.04.2020 to 03.05.2020) resulted in considerable reductions in AQI even below 100 across all locations due to less air pollution and similar observations were recorded during Lockdown-3 (04.05.2020 to 16.05.2020). During 5th phase i.e Lockdown-4, there can be seen increase in AQI values than previous lockdown phases which might be due to relaxations permitted by government wherein few activities were allowed to be operated in areas other than Red Zone and containment areas.

The AQI at almost all stations observed to be less than 150 (moderate conditions), and most of stations showed below 100 AQI (Satisfactory conditions) which clearly depicts the reduction in air pollution.

During 2nd & 3rd phase of stricter lockdown (21.03.2020 to 03.05.2020), all stations show AQI below 150 and 100, except for one of the stations located at MIDC Khutala, Chandrapur - MPCB which is showed above 200 (Moderate conditions) due to presence of working thermal power station.

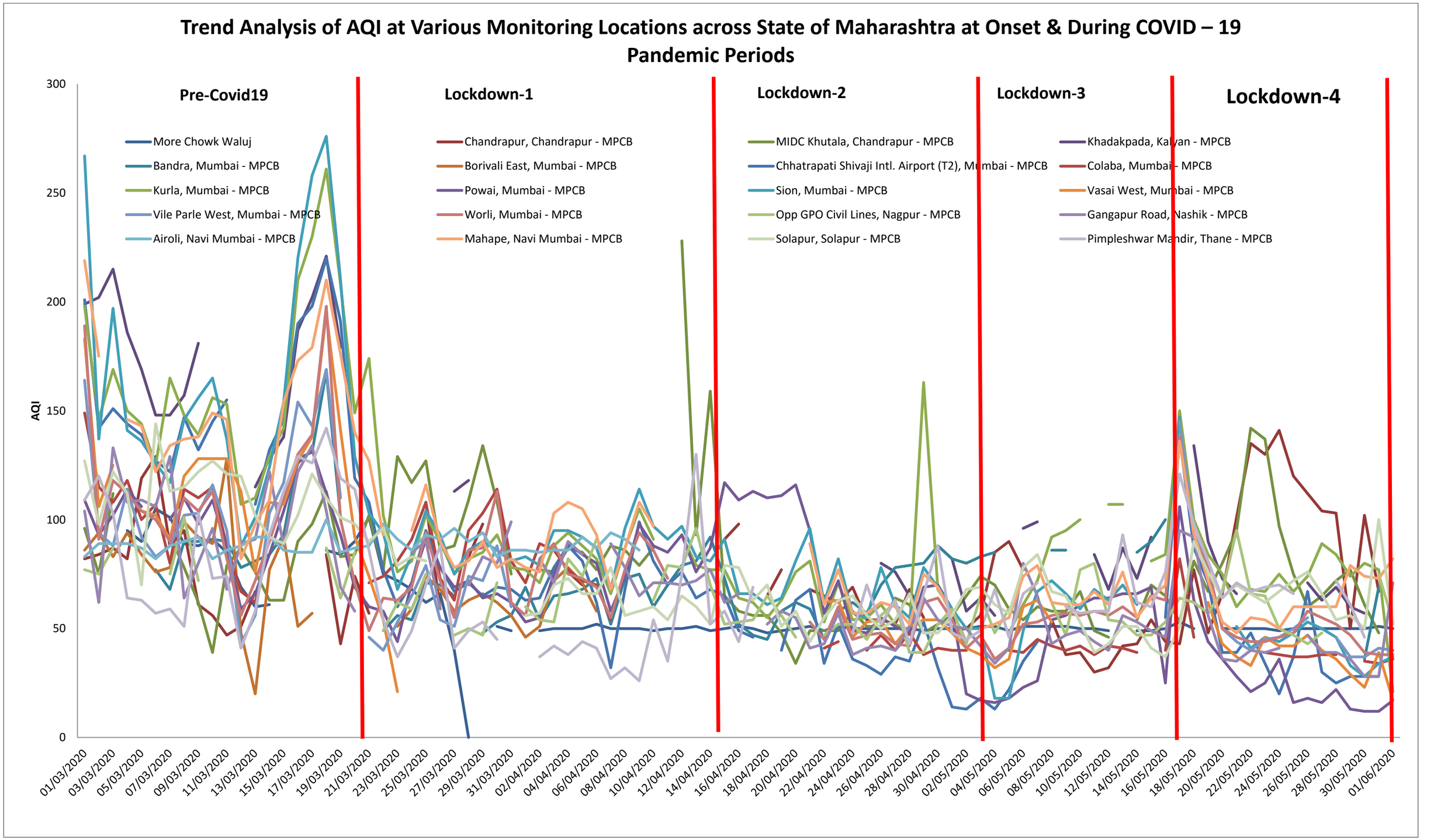


Figure 24 Trend Analysis AQI at Various Monitoring Locations across State of Maharashtra at Onset & During COVID-19 Pandemic Periods

5.1.2.1 Analysis of Air Quality Data in Terms of Specific Pollutants

This study also includes impact of lockdown on specific criteria pollutants such as PM_{10}, NOx and SO_2. The comparison of average concentration of these pollutants pre & post lockdown is specified in **Table 6** and info-graphics for each pollutant is presented in following section.

Table 6 Average concentration of PM_{10}, NOx and SO_2 for Pre & post Lockdown periods at 22 AAQMS in Maharashtra.

Locations	Pre-lockdown 01-03-2020 to 20-03-2020			Lockdown 21-03-2020 to 01-06-2020			% decrease between Pre & post lockdown Period		
	PM_{10}	NOx	SO_2	PM_{10}	NOx	SO_2	PM_{10}	NOx	SO_2
More Chowk Waluj, Aurangabad	84.75	8.35	7.33	44.48	14.95	5.86	40.27	-6.59	1.48
Chandrapur, Chandrapur	82.50	10.21	22.89	75.70	9.68	24.34	6.80	0.53	-1.45
MIDC Khutala, Chandrapur	47.55	16.49	17.08	47.97	14.46	17.74	-0.42	2.03	-0.66
Khadakpada, Kalyan	193.63	36.68	27.44	86.91	13.47	54.32	106.71	23.21	-26.88
Bandra, Mumbai	89.67	71.45	16.01	72.33	14.98	37.07	17.34	56.47	-21.05
Borivali East, Mumbai	89.81	7.57	3.51	64.22	4.60	3.59	25.59	2.97	-0.08
Chhatrapati Shivaji Intl. Airport (T2), Mumbai	166.39	107.63	5.50	52.40	55.14	1.75	113.99	52.50	3.75
Colaba, Mumbai	110.71	29.97	23.59	37.96	19.36	15.81	72.75	10.60	7.78
Kurla, Mumbai	185.50	82.99	42.31	80.42	16.23	17.43	105.09	66.76	24.88
Powai, Mumbai	103.89	15.54	4.31	54.47	4.99	8.86	49.42	10.55	-4.55
Sion, Mumbai	181.08	91.54	9.25	72.83	35.11	11.27	108.25	56.43	-2.02
Vasai West, Mumbai	127.46	69.72	3.90	47.36	53.58	3.48	80.10	16.14	0.42
Vile Parle West, Mumbai	109.75	56.60	16.13	55.44	10.01	11.58	54.31	46.59	4.55
Worli, Mumbai	109.25	46.03	6.42	59.48	7.24	3.98	49.78	38.78	2.44
Opp GPO Civil Lines, Nagpur	67.15	37.29	6.93	43.29	13.59	2.10	23.87	23.70	4.82
Gangapur Road, Nashik	89.21	18.35	3.95	50.31	10.85	2.39	38.91	7.50	1.56
Airoli, Navi Mumbai	40.56	33.66	45.00	40.56	33.93	46.42	0.00	-0.27	-1.42
Mahape, Navi Mumbai	161.33	105.09	17.89	71.43	26.18	10.75	89.90	78.91	7.14
Nerul, Navi Mumbai	177.78	65.65	15.60	70.71	12.86	12.08	107.07	52.79	3.51
Karve Road, Pune	85.34	25.60	45.23	35.51	12.84	23.21	49.83	12.76	22.02
Solapur, Solapur	106.26	62.76	26.25	63.88	5.33	6.29	42.38	57.44	19.97
Pimpleshwar Mandir, Thane	97.63	69.58	29.61	56.03	11.44	8.03	41.60	58.14	21.58

Source: https://app.cpcbccr.com/ccr/#/caaqm-dashboard-all/caaqm-landing/data

From **Table 6**, PM_{10} concentration has significantly reduced across all stations except MIDC Khutala, Chandrapur. Similar to PM_{10}, NOx concentration has also seen to be reduced at majority of stations except 2 viz. More Chowk Waluj, Aurangabad and Airoli, Navi Mumbai. However, SO_2 concentration is observed to be reduced at 13 stations and slightly increased across 8 stations by nearly 2%.

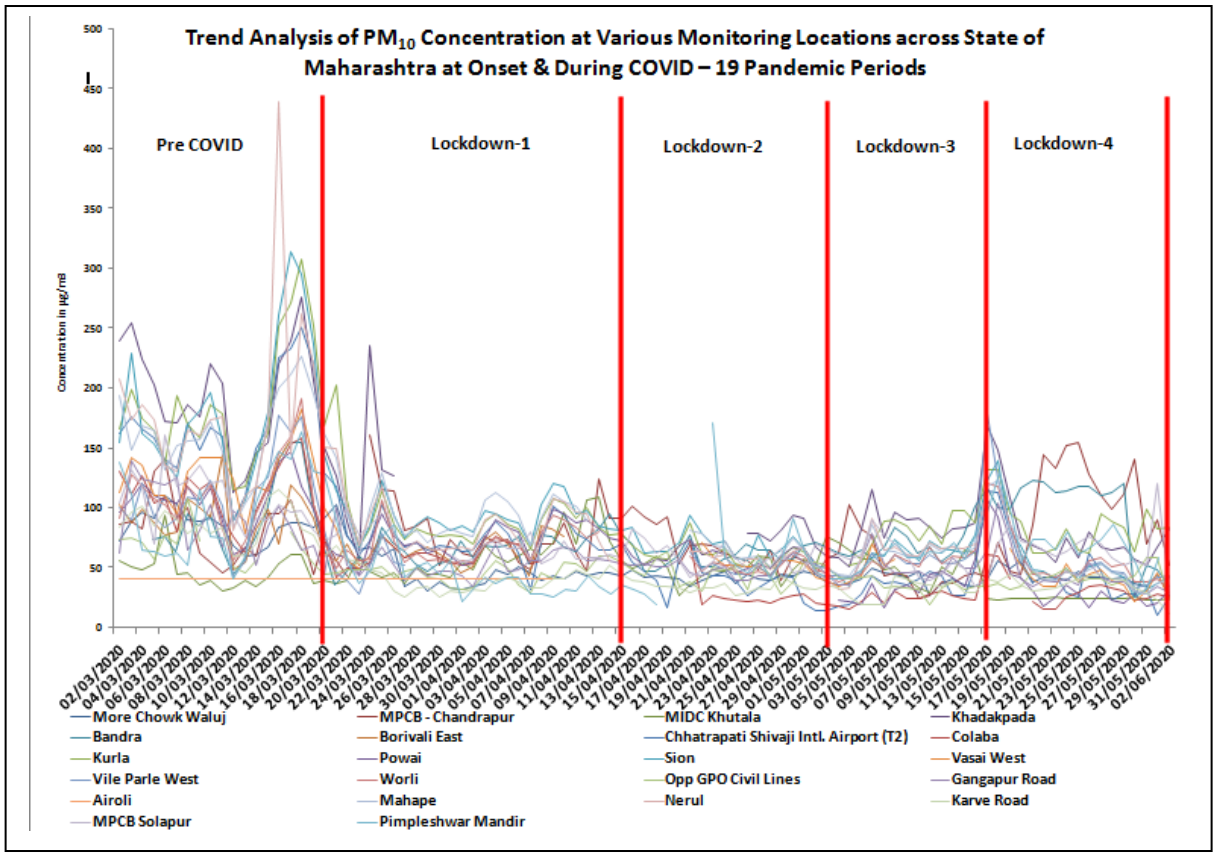


Figure 25 Trend Analysis of PM_{10} Concentration at Various Monitoring Locations across Maharashtra at Onset & During COVID-19 Pandemic Periods

Trend analysis of PM_{10} concentration across all stations in State for five phases at Onset & During COVID-19 Pandemic Periods as represented in **Figure 25**, wherein air quality is observed to be improved. It can be predicted that PM_{10} concentration is significantly reduced during lockdown 1 & 2 from 250µg/m^3 upto 100µg/m^3 as compared to 1st phase. During 4th & 5th Phase of Lockdown- 3 & 4 slightly gradual increase in concentration is observed upto a range of 150µg/m^3 due to relaxation allowed for few activities by Government though it is much better than 1st phase of Pre- COVID-19 scenario.

Similar to PM_{10}, trend analysis of NOx concentration is observed from **Figure 26**. At the end of 1st phase increased concentration upto 200µg/m^3 beyond average upto 150µg/m^3 can be seen which might be due to increased migration activities. Further during lockdown phases it is observed to be considerably reduced below 50µg/m^3 except 5th phase i.e. Lockdown 4 which shows slight increase in concentrations at stations viz. Sion, Colaba, Chatrapti Shivaji International airport.

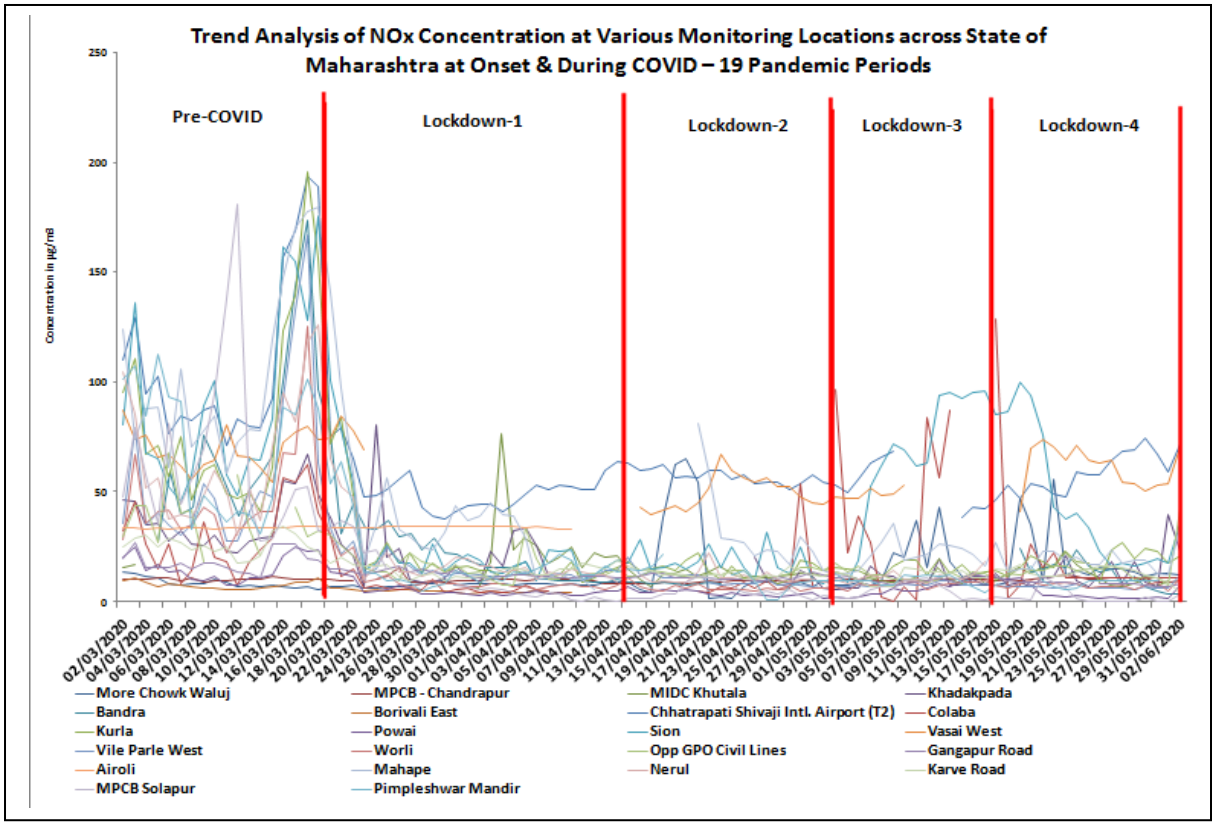


Figure 26 Trend Analysis of NOx Concentration at Various Monitoring Locations Maharashtra at Onset & During COVID-19 Pandemic Periods

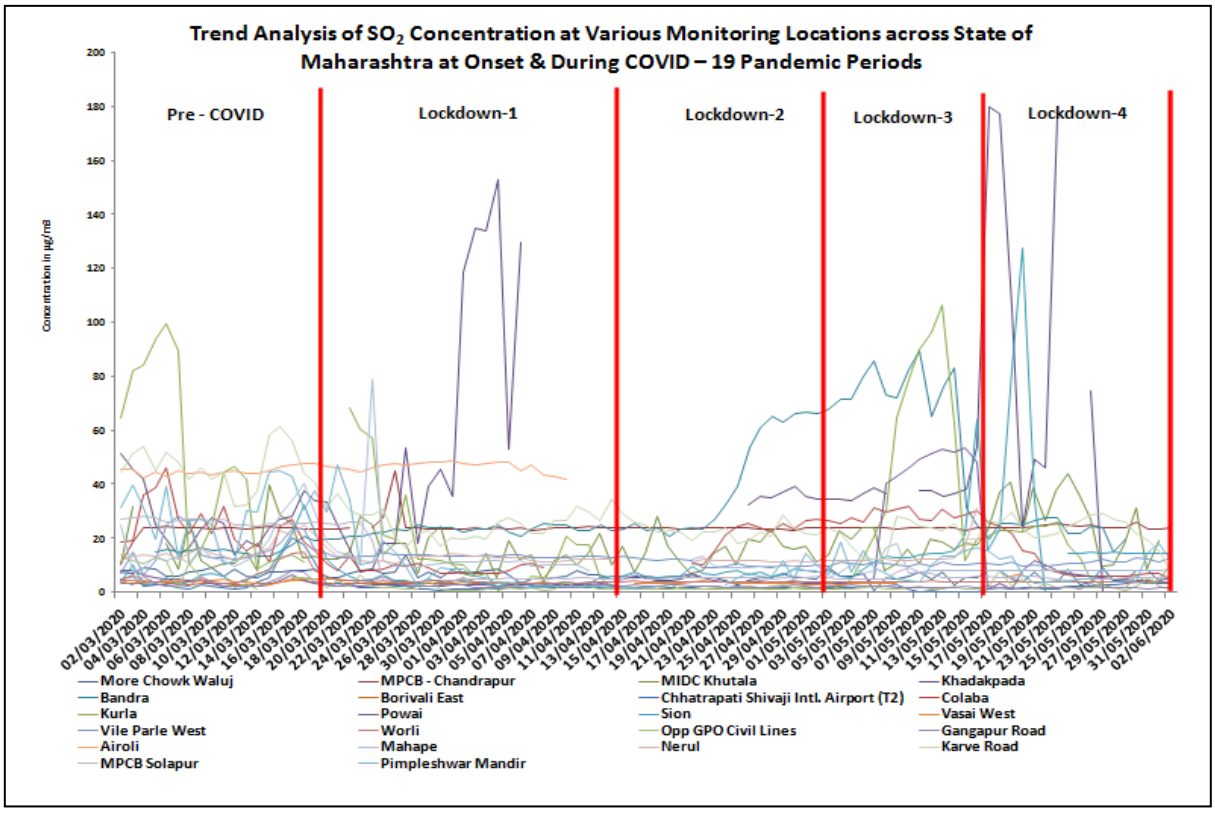


Figure 27 Trend Analysis of SO_2 Concentration at Various Monitoring Locations across Maharashtra at Onset & During COVID-19 Pandemic Periods

Trend analysis of SO_2 during the study period represents these scenarios much scientifically. Similar to other pollutants, From **Figure 27**, reduction in concentration is observed across all stations during lockdown phases by an average of 40µg/m^3 from Pre-lockdown except two / three stations i.e. at Bandra, Kurla & Khadakpada-Kalyan. During Lockdown 3 & 4, Khadakpada-Kalyan station shows very high concentration than all other locations. It is to be noted that during these phases few activities were permitted including interstate travels after certain permissions as per lockdown policy. Khadakpada-Kalyan is a location on busiest Nashik –Thane Highway with maximum traffic of heavy duty vehicles which uses higher Sulphur content fuels. On the other hand, thousands of migrant workers travelled from this route to reach MP, UP and other parts of North India as most of the Shramik trains and buses were deported from Nashik & Dhule to these places. Thereby it can be predicted that higher concentration at this location is a result of these heavy duty vehicles movement.

In conclusion it is clearly depicted that Air Quality Index (AQI) has improved across all the stations. The Air Quality Index (AQI) at almost all locations in Mumbai have improved from Moderate to Satisfactory Criteria which was never observed before and for the First time in after really long, AQI for all stations across the State as now observed in “Satisfactory” Criteria.

In terms of three criteria pollutants (PM_{10}, NOx and SO_2); concentration has been increased only at 1, 2 & 8 stations respectively however, trend analysis for these pollutants show significant reduction in concentration at all locations during the lockdown phases.

5.1.3 Impact on Noise Environment

Environmental noise is defined as an unwanted sound that could be generated by anthropogenic activities (for instance, industrial or commercial activities), the transit of engine vehicles, and melodies at high volume.
The imposition of quarantine measures by most governments has caused people to stay at home. With this, the use of private and public transportation has decreased significantly. Also, commercial activities have stopped almost entirely. All these changes have caused the noise level to drop considerably in most cities across the state.

There has been empty road thus no honking, no whirr of vehicular engines, no echo of loudspeakers, no commercial events and no clanking of machineries in factories. These all are the factors for considerable reduction in Noise levels in urban areas of mega cities. However it needs to be considered that this is a temporary impact and as lockdown will be released, in the future, more careful planning and management shall be planned in order to control the unwanted noise levels.

5.2 Water Environment

For decades, the hydrosphere that includes lakes, rivers, oceans, and groundwater reservoirs has been severely polluted because of rapid urbanization, industrialization, and overexploitation. During the lockdown period, the major industrial sources of pollution that affect aquatic ecosystems, such as industrial wastewater disposal, crude oil, heavy metals, and plastics (Häder et al. 2020), have shrunk or completely stopped. Therefore, the level of pollution is expected to be reduced.

The absence or slowdown of economic activities during lockdown has supported environment to undergo a self-revival to a certain degree and also realized the extent of contribution of the domestic sources to the river pollution. There are many reasons for media reports suggesting improvement in water quality in rivers and the river water seems cleaner. Though there are many reasons for observational improvement in water quality, Industrial discharge & limited human activities around them are definitely the ones. Improvement in aquatic pollution in rivers in water bodies is a function of both quality and quantity. With

reduced consumption by both industries & agriculture i.e. withdrawal from resources there is an expected higher than average relative flow of water enhanced by lowest pollution sources adding more life to the aquatic regimes. Human domestic activities at Ghats of major rivers are also being shut to the public as well as all traditional rituals / Puja waste & other allied waste dumping phenomena around the rivers significantly seems to be reduced during this period. The clear water as per media reports is a result of all these along with many other such factors imposed due to restrictions.

Water quality across the State is objectively analyzed to evaluate the effect of lockdown in various regimes through existing MPCB water quality monitoring network. To study this effect data from MPCB's online portal has been is considered as presented in following section.

Similar is the case with wastewater, it is estimated that about 9,759MLD of sewage is generated in ULB's of which the 27 Municipal Corporations generate about 7,696MLD. On an average 60.8% of urban gets treated & whereas the sewage generated from rural areas of about 2,063 MLD is almost untreated making it about 3819 MLD being released untreated in the surface water bodies & on land. MPCB regularly monitors water quality across 250 water quality monitoring stations for both surface (155 on rivers, 34 on sea/ creeks, 10 on drains, one on dam) and ground water (24 bore wells, 24 dug wells, one hand pump, one tube well) under National Water Monitoring Program (NWMP). Surface water samples are monitored every month for nine core parameters and 19 general parameters whereas the ground water samples are monitored every six months to trace metals and pesticides. Water quality at 39 locations of Godavari, Krishna, Panchganga and Bheema rivers in the State during 2018-19 is given in **Table7,** Water quality index for various river basins in the State during 2019 is given in **Table 8**. Hon'ble NGT order in OA No. 673/2018- "More river stretches are now critically polluted: CPCB", there are around 4 polluted river stretches in each Priority I & II and 8,15 & 19 stretches in Priority III, IV & V respectively as on January 2020.

Table 7 Water Quality At Monitoring Stations On Selected Rivers During 2019

Station Name	pH	Dissolved Oxygen [mg/l]	BOD [mg/l]	COD [mg/l]	Nitrate [mg/l]	Fecal Coliform [mg/l]
Krishna River At Rajapur Weir	7.80	6.66	2.12	13.67	1.11	10.31
Godavari River At Jaikwadi Dam, Paithan	8.00	6.69	3.34	11.00	0.62	2.00
Mula-Mutha River At Mundhwa Bridge	7.58	2.53	12.43	38.00	2.74	512.50
Kanhan River [Wainganga Basin] At Downstream of M/s. Vidharba Paper Mills	8.26	6.80	5.57	21.67	2.50	31.75
Purna River At Dhupeshwar At Upstream of Malkapur Water Works	8.12	7.10	3.73	15.20	3.90	35.90
Darna River At Aswali [Darna Dam]	7.74	6.30	3.23	17.33	1.06	0.77
Savitri River At Muthavali Village	8.91	7.76	2.80	39.60	0.81	6.28
Mithi River At Near Bridge	6.92	2.74	24.92	69.00	1.58	2,545.0

Source: MPCB BOD: Biochemical Oxygen Demand, COD: Chemical Oxygen Demand

Table 8 Water Quality At 39 Locations of Godavari, Krishna, Panchganga, and Bheema Rivers In The State During 2018-19

Parameters							
pH Value		**Biochemical Oxygen Demand**		**Dissolved Oxygen [mg/l]**		**Fecal Coliform [mg/l]**	
6.0 to 9.0#		**Less than 3mg/l#**		**More than 4mg/l#**		**N.A.**	
Range	No. of Locations	Range	No. of Locations	Range	No. of Locations	Range	No. of Locations
5.5 - 6.4	0	2.5 or Less	8	Below 3	1	0 - 100	30
6.5 - 7.4	6	2.5 - 5.4	22	3 - 4.9	6	100 - 200	7
7.5 - 8.4	33	5.5 - 8.4	5	5. - 6.9	29	200 - 300	1
8.5 - 9.5	0	8.5 - 11.4	2	7 - 8.9	3	300 & Above	1
		11.4 & Above	2	9 & Above	0		

Source: MPCB mg/l: milligram per litre, #CPCB Water Quality Criteria, Class C: N.A.: Not Available

5.2.1 Activity Mapping for Attributes Related to Water Quality

Industrial sector has been hit in many ways due to the COVID-19 effect. With respect to COVID-19 pandemic, the quarantine policies established in the states have caused almost every activity except essential services to stand still unexpectedly for considerable period that it will surely have an impact on all aspects of business right from cradle to grave.

Basic Assumptions

- As in case of air, 52,000 with usual excessive and estimated operational capacity represents 92,000 industries
- 53,255 industries represents Pre Covid whereas 9102 industries were permitted during as on Unlock 1.0 to evaluate industrial impact scenario in Maharashtra
- L1 represented by 2362 Nos. with essential industries
- L2 represented by 5372 Nos. with essential & allied industries
- L3 represented by 7414 Nos. with essential, allied & other permitted industries
- L4 represented by 9102 Nos. with all permitted & active industries in last phase

5.2.1.1 Industrial Activity

Data from about 54,085 industries that were gathered for analysis is already discussed under the Section on Air Quality and continue to be the baseline for water environment too as per MPCB records. The effluent generation from industry is 403.69MLD and 308.27MLD sewage is generated. However during 1st phase of lockdown only 2,362 industries out of total were operating which are manufacturing essential goods such as medicines, APIs, health related services / products etc.

Data Assumptions		
Industrial Use		From Received database of MPCB for each phase of the study period
Water Consumption	Consumption for Process (MLD)	The available data could not be used as it is & thereby this particular aspect is still a grey area & in-depth analysis of MPCB database required
	Consumption for Utility (MLD)	
	For Domestic in Industries (MLD)	Calculated from working staff in industries using MPCB database 45lpcd for SSI considering limited canteen facility 60lpcd for MSI & LSI considering cooking facility available in most of them
	Total Water supplied by MIDC's	Due to the limited time & resources, data available with MPCB is only utilized for all practical purposes

	Total Water supplied by Irrigation Dept to Industries	
Wastewater from Industries		
	Effluent generated from Industries (MLD)	Pre COVID effluent from MPCB database During COVID data calculated from % of working industries using actual database of MPCB correlating with permitted industrial activities
	Sewage generated from Industries (MLD)	Sewage = 80% of domestic use for industries as per CHHEOO manual
	Total Effluent received by CETP's	Due to the limited time & resources, data could not be retrieved
Disposal of Effluents		
Effluent are mostly regulated and/or connected to CETP's OR are ZLD & approach towards maximum reutilization within premises whereas industrial CETPS' dispose to surface water body		
	Disposal on Land (MLD)	Disposal on land = 10% @ 10mg/l BOD
	Disposal in River (MLD)	Disposal in river = 75% @ 20mg/l BOD
	Disposal in Sea (MLD)	Disposal in sea calculated from no of coastal districts = 15% @ 30mg/l BOD
Domestic Sector		
Population	Total Population	Population data from census & projected for March 2020 using growth rates as per Economic Survey of Maharashtra
	Urban Population	
	Rural Population	
	Consumption (MLD)	Urban consumption = 197.77 lit/capita/day
		Rural consumption = 45 lit/capita/day
Wastewater from Domestic Sector		
	Sewage Generated (MLD)	Sewage generated assumed to be 74% from back calculated for data from District Environmental Plans prepared by MPCB for ULB's & adjusted for rural to match total load
	Treated Sewage (MLD)	Treated sewage = 30% of total sewage to the acceptable standards
	Untreated Sewage (MLD)	Untreated sewage = 70% of total sewage
	BOD load for Treated Sewage per day (TPD)	BOD load for treated sewage = 10 kg/MLD
	BOD load for Untreated Sewage per day	BOD load for untreated sewage = 100 kg/MLD
Disposal of Domestic Sewage		
	Disposal on Land (MLD)	Calculated from districts near coast (sea) & river whereas the remaining assumed on-land for irrigation
	Disposal in River (MLD)	Land = 14% of total
	Disposal in Sea (MLD)	River = 58% of total
		Sea = 28% of total

Figure 28 represents total operational industries vs. permitted industries during each phase of lockdown period along with population employed industrial sector in the State. Maharashtra deploys about 65 Lakh working strength in these industries wherein the number of individuals through various phase of lockdown shows marked reductions with just about 12Lakhs being functioning by end of L-IV against 4 Lakhs during L-I i.e. only about 6%as against Pre-lockdown phase. However, it seems that the permission granted gradually increase the working population to 12%, 16 & 20% respectively during L-II to end of L-IV.

Figure 29 represents domestic water consumption in industries pre-COVID-19 & during each phase of lockdown. It has been observed that the industrial domestic water consumption is reduced by almost 94% during 1st phase of lockdown (i.e. from 385.34MLD to 23.24MLD) due to absolute restrictions on non-essential industrial manufacturing. During

subsequent 2nd, 3rd & 4th phases, the reduction in industrial domestic water consumption was observed to be 88%, 84% & 81% as industries gradually started operating with permissions.

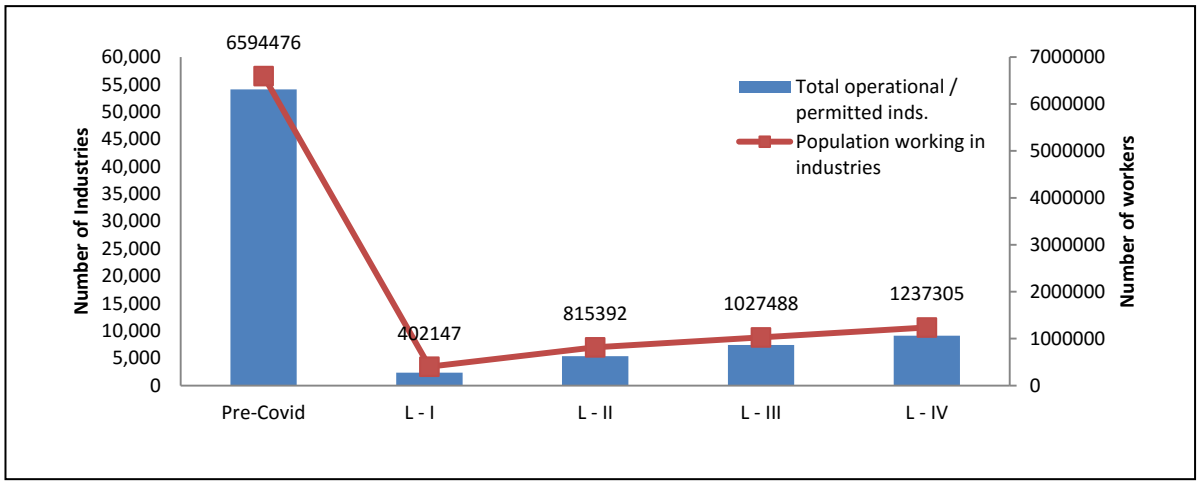


Figure 28 Total operational industries vs. permitted industries with working population during phase-wise lockdown in State

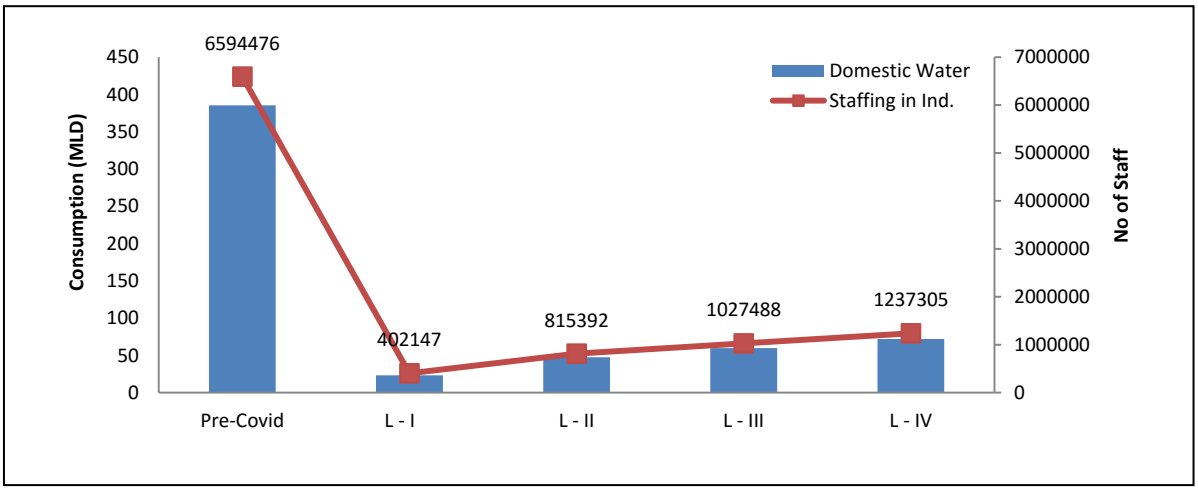


Figure 29 Effect of lockdown on domestic Water requirement and sewage generation

Reduced resource consumption directly translated into waste generation significantly reducing wastewater generation from industries as depicted in **Figure 29** during 1st phase of lockdown showing 95% sewage reductions whereas effluent generation by whooping 93% as compared to the normalcy (pre-lockdown) period.

It gradually increased with permitted activities being advanced in industries but still continued to shows remarkable reductions by at least 80% & 81% for effluent and sewage respectively by the end of L-IV. The percolating effect of such reductions was also computed for the waste finding its way into nature affected through its disposal paths as presented in **Figure 30** & **31** showing almost 95% reductions on the overall pressure on nature. Overall, computing for the organic load reductions from domestic sewage into the various natural course, during entire phase of lockdown with restricted activities, it seems that out of the 1656ton of BOD load that been avoided, 1035tons was avoided flowing into rivers, 434tons into sea & 187tons On land during the entire period of lockdown considering both the industrial & domestic activities as presented in **Figure 33** whereas the share of sectors during various lockdowns is presented in **Figure 32.**

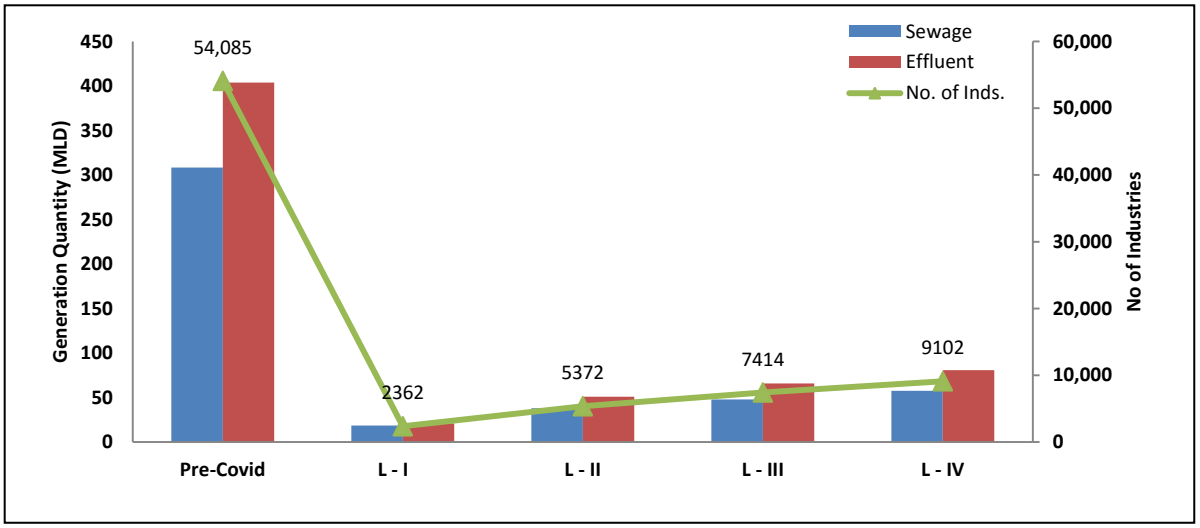


Figure 30 Effect of phase-wise lockdown on sewage and effluent generation from industries

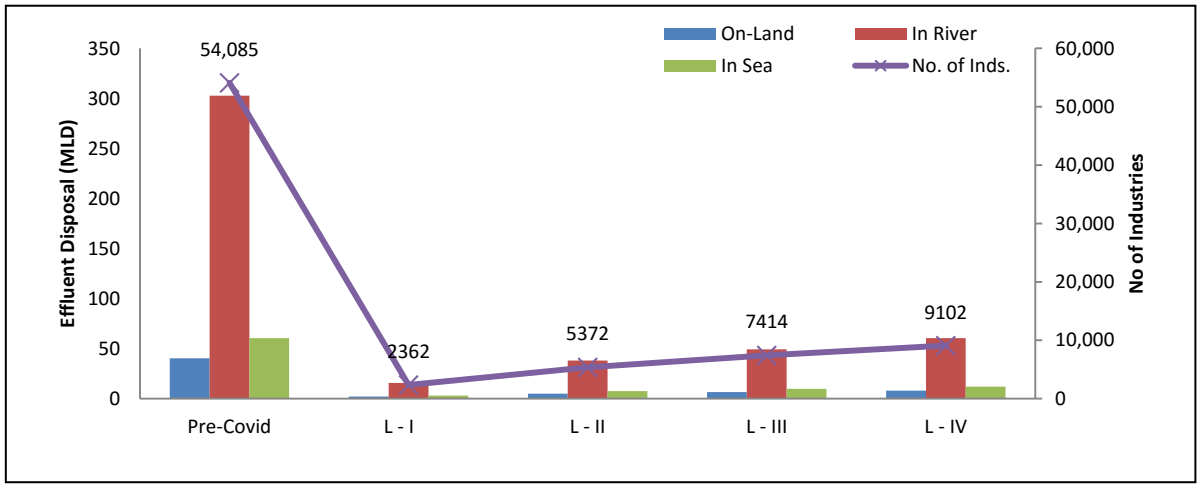


Figure 31 Effect of phase-wise lockdown on disposal of sewage and effluent generation from industries

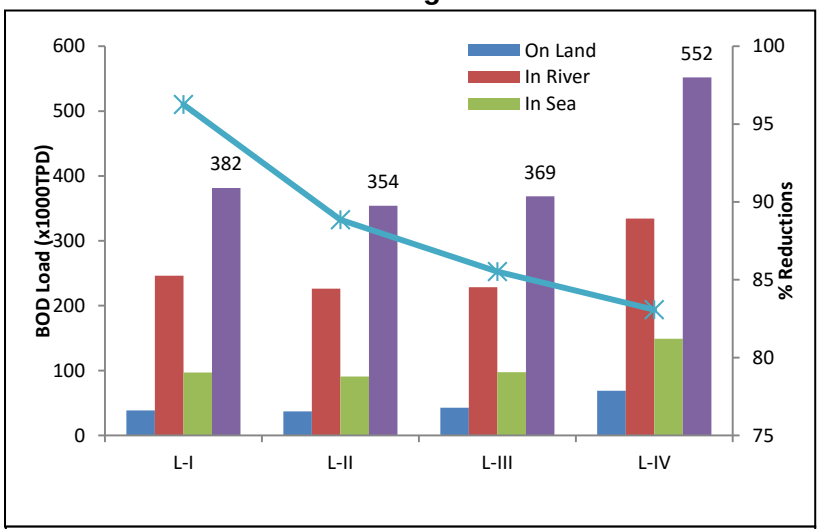


Figure 32 % reduction in BOD load from disposal of effluent on Land, River & Sea

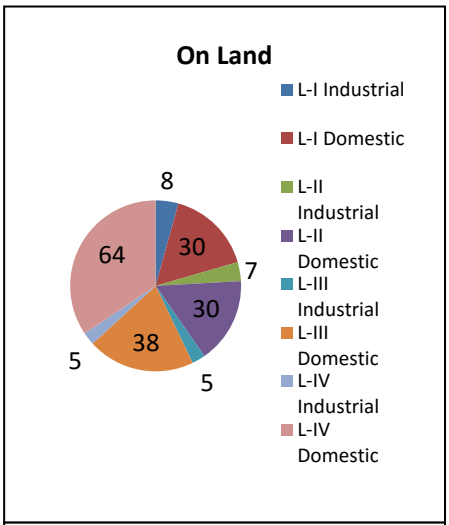


Figure 33 Disposal share of sectors during lockdown

5.2.1.2 Domestic Activity

The lockdown has made the entire population to be home-ridden whereby most of the domestic sectoral water consumptions patterns are expected not to change though some of the factors such as migrant population changes only is expected to the drive pattern changes in the overall water quantity & thereby disposal. However**,** the lifestyle changes & its impact in water consumption / use patterns due to being life restricted at home is a matter of further research & beyond scope of this study.

Figure 34 represents impact of one of the vital factors considered in this case i.e. movement of migrant population during lockdown as per the regulations imposed by government from time to time. The average daily water consumption during pre-COVID-19 period is 13,161MLD which due to migration is reduced by 1.27% during 1st phase whereas migrants being restricted showed only 0.37% reduction in L-II & with government arranging for public mass migration at beginning of L-IV water consumption & sewage was further reduced by almost 1.29% to 12,782MLD. This in turn reduced pressures on disposal pathway as well as organic load though to a very marginal extent i.e. 0.14% on land, 0.58% in river & 0.28% in sea as compared to that during pre-COVID-19 period as presented in **Figure 35.**

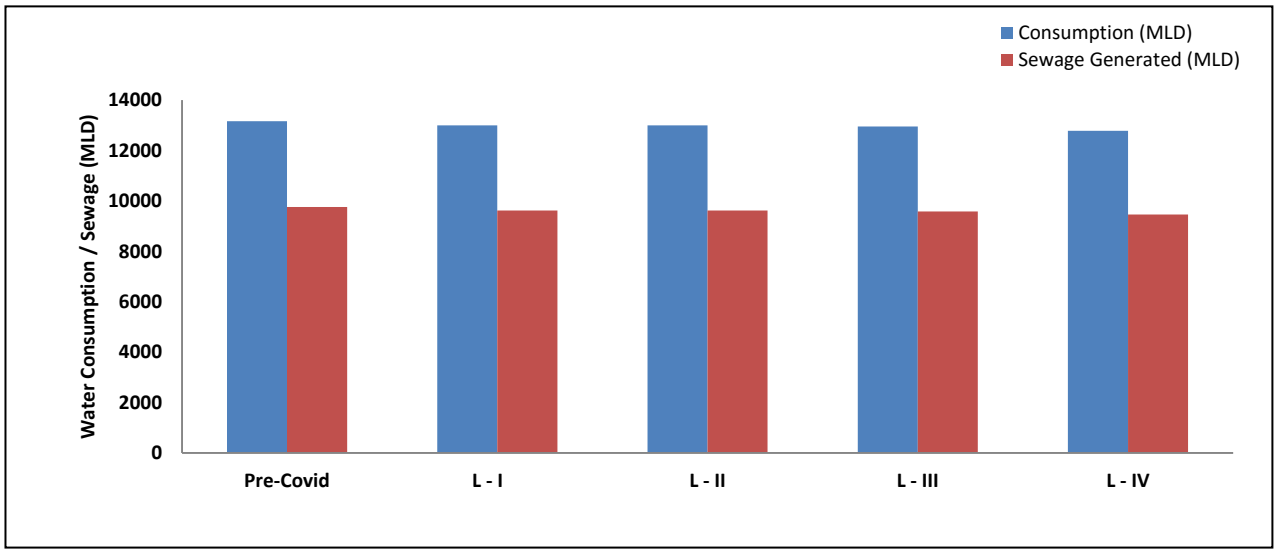


Figure 34 Effect of lockdown on domestic water consumption and sewage generation

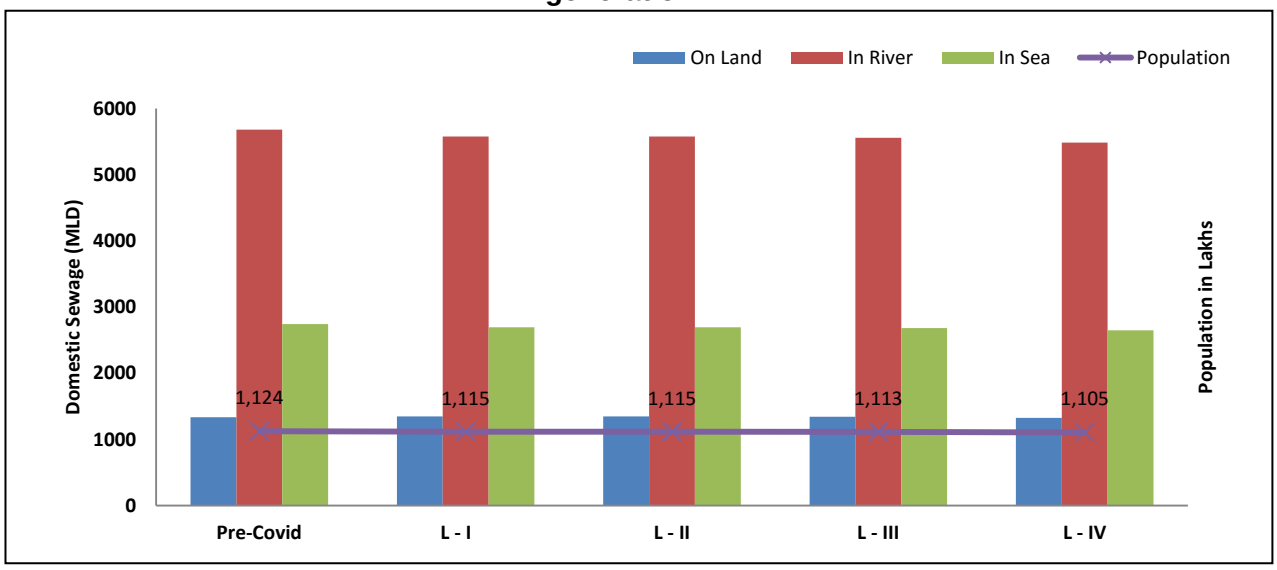


Figure 35 Status of domestic sewage disposal during lockdown period

The translation of these reductions in quantity of sewage further suggests an overall reduction of 163, 675 & 6326 tons of BOD on land, in river & sea respectively considering the disposal pathway as assumed & computed thereby totally avoiding 1164 tons during lockdown period as a whole.

The reduced load of organics & other parameters of water quality from various sectors of activities as discussed in earlier sections needs to be further assessed for its applicability. Thereby, it is only appropriate to compare month wise data for similar time periods of respective seasonal conditions across April of 2018-19 & that of 2020 to evaluate the corresponding impact of COVID-19 *on water quality. Water quality comparison has been carried out for physical parameters such as pH, BOD, COD & DO for both years at similar monitoring locations & presented for all the monitoring locations across Maharashtra.*

Quality of surface water is monitored every month across 200 water monitoring stations (WQMS) by MPCB under Central Pollution Control Board's project of NWMP. Basin-wise water quality in terms of pollution concentration is presented in this section

5.2.1.2.1 Tapi River Basin

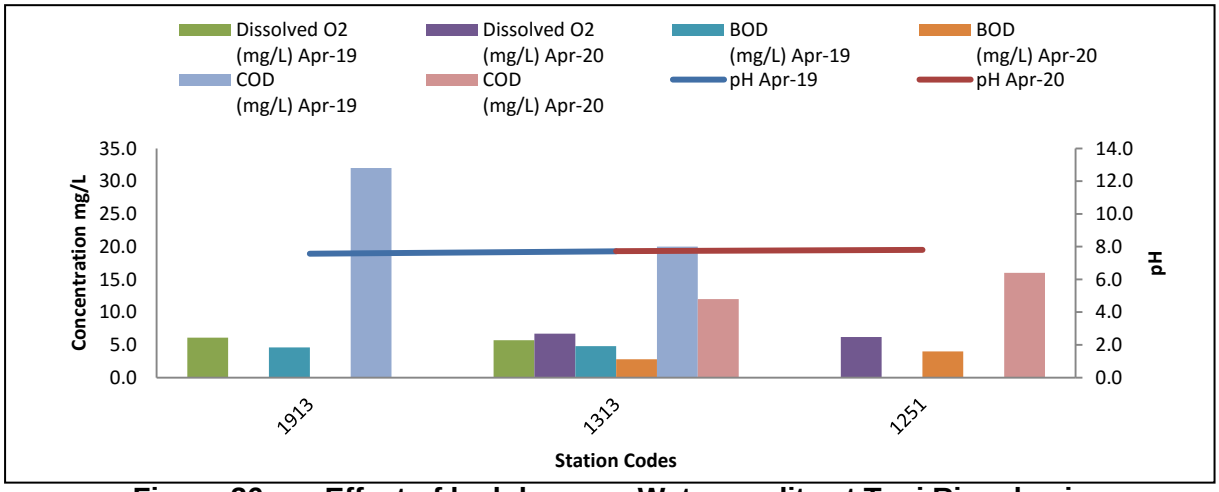


Figure 36 Effect of lockdown on Water quality at Tapi River basin

Though only 3 stations out of 20 have been able to be assessed for sampling during this period due to dried up stretches at several of the monitoring sites, comparative data for all parameters considered is available only at one of these locations (**i.e. 1313**), in Jalgaon District for both years as presented in **Figure 36.** Though statistically not a very impressive analysis, data if extrapolated seem to suggest the stretch having witnessed BOD reduction of about 41.7% , COD by 40 % however no reduction whereas consequently & rightly so, the DO is increased from 5.7 to 6.7mg/l which in itself reveals substantial improvement.

5.2.1.2.2 Godavari Basin

Godavari River basin is monitored at 48 locations for its water quality, of which data for 31 stations is available for comparison of during both the years. The impact of lockdown is prominently revealed across most of the monitoring locations as presented in **Figure 37** depicting BOD reduced at 25 locations by an average of approximate 25.8%, COD is reduced at 20 locations by an average of about 82% whereas DO is increased sharply by about 33.8% at 26 locations. Similarly, nitrates & Faecal Coliforms also show marked reductions at 50% of the locations that could be compared.

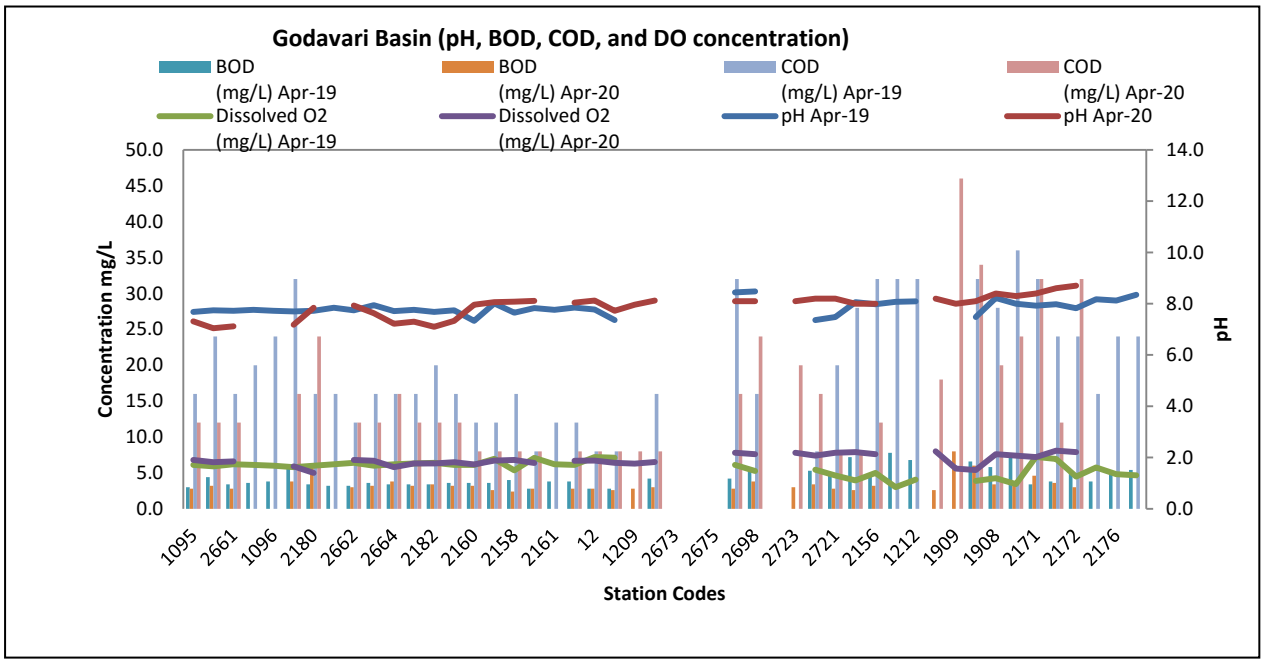


Figure 37 Effect of lockdown on Water quality at Tapi Godavari basin

5.2.1.2.3 Krishna Basin

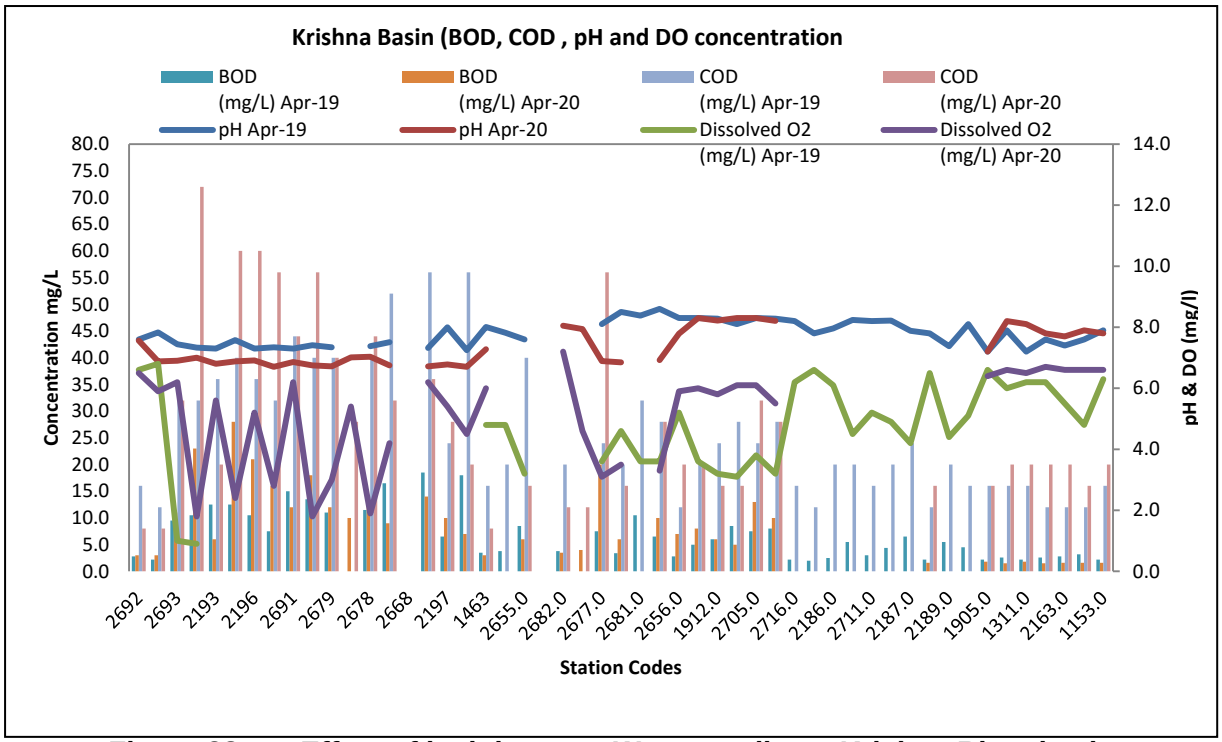


Figure 38 Effect of lockdown on Water quality at Krishna River basin

Water quality in Krishna River basin is evaluated at 51 locations, however for comparative account is available at only 26 locations as depicted in **Figure 38.** In this case too, BOD is reduced at 33% locations by almost an average of 33.2%, COD is reduced at 24% locations by average 42.7% and DO is increased at 33% locations by average of 22.3%. Though there are several locations with marginal increase in concentrations of these parameters, it can be easily depicted that almost 1/3rd of the stretch shows better water quality in Krishna basin

including that for Nitrates & Fecal Coliforms that show reductions at about 40% locations by an average range of 25-40%.

5.2.1.2.4 West Flowing Rivers

The West Flowing River basins too like the case of other discussed rivers show marked variations in water quality when compared for available data at 28 out of total 34 monitoring locations. As represented in **Figure 39** BOD seems to be reduced at 71% locations by an average of 29.4% & COD is reduced at 27% locations by average 32.6%. In terms of consequential impact of reduced organics, the DO is increased at 40% locations by average of 8.1%. Furthermore, the cleaning process is adjudicated by reduction in nitrate concentrations at 70% locations by almost 90% value & Fecal Coliforms by 76.8% at again 70% of the locations thereby assuring the impact to be extremely positive in these rivers.

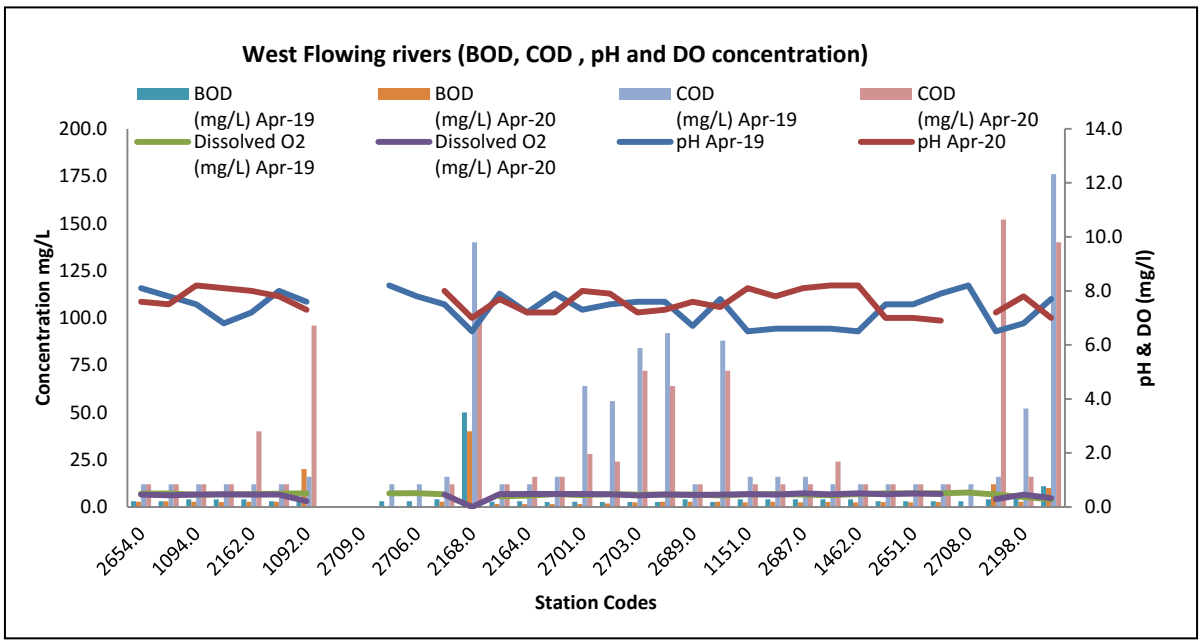


Figure 39 Effect of lockdown on Water quality at West Flowing River basin

Not only limited to the rivers, the nallahs that are monitored for evaluation of water quality possibly carrying waste streams into the surface water bodies also show remarkable reductions in terms of BOD reduced by an average of 43.1% & COD by average 28.9%.

5.2.1.2.5 Saline Basins

The evidence that the quantity of wastewater from both industries & domestic sector translated to the extent of organic load reduction as deduced in activity data for water related environmental attribute is provided by not only the riverine quality improvement but also the sea water quality enhancement as compared to the April 2019 data available at 29 locations as represented in **Figure 40.** BOD is reduced at 52% locations by an average of 15.3% & COD is reduced at 21% locations by average 22.4% though there are certain locations that show marginal increase too may be due to some localized activity in that zone. DO too represent similar trends with 62% locations showing an increased value by an average of 12.7%.

Summarizing the effectiveness of water quality improvement, total 125 locations were monitored for analyzing quality of water during the month of April 20 that were compared with the April 2019 database from MPCB.

Out of the 6 river basins, it is found that almost all of the basins at considerable locations show improvement in the water quality which in terms of BOD are found at 84% of locations

whereas for COD at almost 65% of the locations (viz. Tapi, Godavari, west flowing rivers & Nallah basins) whereas the other 2 River basins shows improvement at 30% locations.

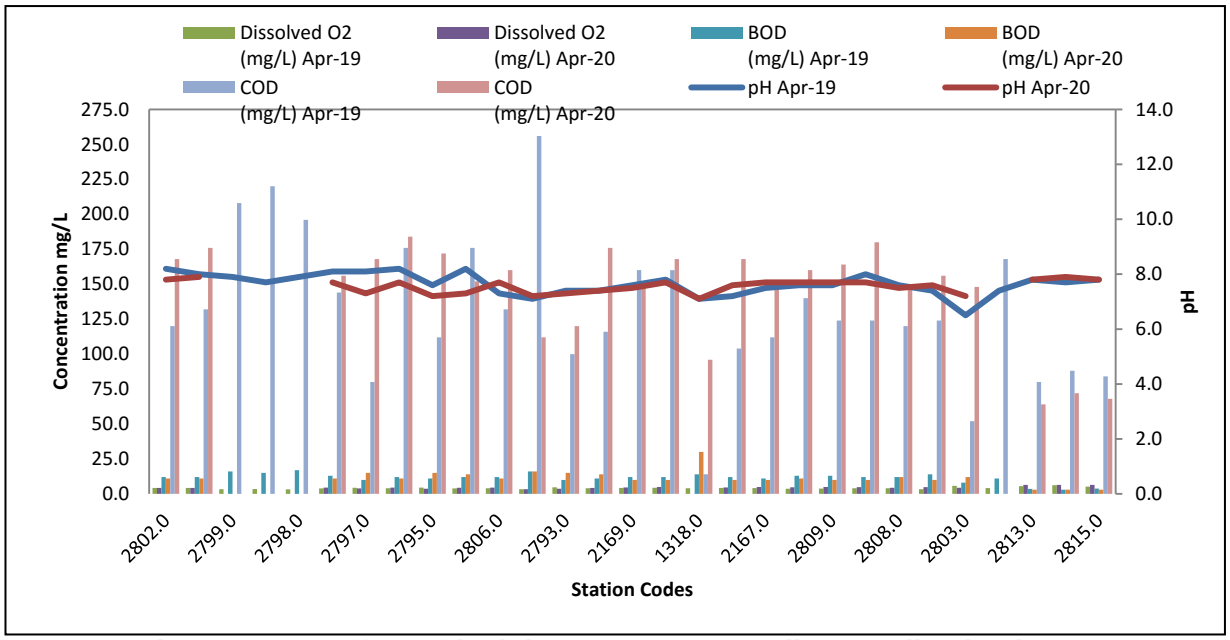


Figure 40 Effect of lockdown on Water quality at Saline basin

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There is some incongruity observed at certain locations i.e. about 16% for BOD & 36% for COD representing marginal increased concentrations during this period that might be due localized events / discharges or some similar phenomena. pH of water at all locations was observed to be varying in the range of 7-9 for both April'2019 & April'2020 period & DO is proportionally increased wherever the organic contents are observed to be lowered.

5.3 Impact on Waste Generation

Each country is at a unique stage of this pandemic and has different set of problems to deal with. Governments are pushing for social distancing, stay-at-home orders, and testing to minimize public interactions and spread which indirectly also have affected waste generation practices to a different stage altogether. These actions have created ripple effects on the functioning of entrepreneurs, businesses, corporations as well as industries which also resulted into a large mass of migrant workers moving back to their hometowns for living.

The first and foremost impact on waste generation seen is the temporary relocation of certain workforce from offices to home setting and shutting down of industries. To perform engineering, designing, planning, or construction work, professionals are expected to be physically present in offices or on the sites. Interaction and coordination with other disciplines such as electrical, mechanical, and other staff members is an integral part of the consumerism and waste generation system.

Impacts of lockdown on solid waste generation in Maharashtra are studied and compared with usual pattern of waste generation before lockdown period. The analysis results are explained in following sections of this report.

5.3.1 Impact on Solid waste

Each country is at a unique stage of this pandemic and has different set of problems to deal with. Governments are pushing for social distancing, stay-at-home orders, and testing to minimize public interactions and spread which is expected to indirectly affect not only waste generation quantities but also quality & characteristics. These actions have created ripple

effects on the functioning of entrepreneurs, businesses, corporations as well as industries which also resulted into a large mass of migrant workers moving back to their hometowns for living along with changes in consumerism patterns.

The first and foremost impact on waste generation seen is the temporary relocation of certain workforce from offices to home setting and shutting down of industries thereby altering the geospatial distribution of solid waste generation. Interaction and coordination with other disciplines such as electrical, mechanical, & work members is an integral part serving as determinants of consumerism & waste generation system.

Impacts of lockdown on solid waste generation in Maharashtra are studied and compared with patterns of waste generation before lockdown period. The analysis results are explained in following sections of this report.

5.3.1.1 Activity Mapping for Municipal Solid Waste

On an average every day 50,000 MT waste is generated in the State; of which about 23,707MTD is from ULB's whereby about 88% is collected via door to door reachout. About 60% of the waste collected is segregated in the wet and dry form whereas 55% of collected waste is processed. Solid waste generated in the State is being treated in 56 common facilities provided either by Municipal Corporation or Municipal Councils and 7 Cantonment Boards. Of the total solid waste generated, 52.9% Solid waste is treated per day. All 384 cities in the State have started the process of segregation. All 384 cities from the State participated in the Survekshan. In top 100 AMRUT rank holders, 29 were from Maharashtra. In top 100 non AMRUT rank holders, 83 were from Maharashtra. Out of 193 awards 46 were grabbed by Maharashtra which was highest by any state.

<table>
<tr><td colspan="4"><u>Data Assumptions</u></td></tr>
<tr><td colspan="4">Industrial</td></tr>
<tr><td rowspan="5">Domestic (Ind.)</td><td colspan="3">From Received database of MPCB for each phase of the study period</td></tr>
<tr><td>Biodegradable (TPD)</td><td rowspan="4" colspan="2">Calculated from working population
SSI= 0.1kg/capita/day
LSI + MSI = 0.2kg/capita/day
Biodegradable= 60% of total waste and Non Bio + 40% of total waste</td></tr>
<tr><td>Non - Biodegradable (TPD)</td></tr>
<tr><td>Inerts (TPD)</td></tr>
<tr><td></td></tr>
<tr><td rowspan="3">Hazardous Waste Generation (TPD)</td><td>Incinerable (TPD)</td><td rowspan="6" colspan="2">Data gathered from MPCB as well as the CHWTSDF & reference drawn from Annual Report of MPCB, Economic Survey of Maharashtra, 2019</td></tr>
<tr><td>DLF - Direct Land filling (TPD)</td></tr>
<tr><td>LAT – Land filling After Treatment (TPD)</td></tr>
<tr><td rowspan="3">Waste Received by CHWTSDF (TPD)</td><td>Incinerable (TPD)</td></tr>
<tr><td>DLF - Direct Land filling (TPD)</td></tr>
<tr><td>LAT – Land filling After Treatment (TPD)</td></tr>
<tr><td colspan="4">Municipal Solid Waste</td></tr>
<tr><td rowspan="5">Population & Generation</td><td>Total population</td><td colspan="2" rowspan="4">Population data from census & projected for March 2020 using growth rates as per Economic Survey of Maharashtra computing Rural & Urban population
Lockdown period calculations are based on migrant population as done in case of Water data</td></tr>
<tr><td>Urban Population</td></tr>
<tr><td>Rural Population</td></tr>
<tr><td>Waste Generated (TPD)</td></tr>
<tr><td>Biodegradable (TPD)</td><td colspan="2" rowspan="2">Waste Generation = 0.45 kg/capita/day for both urban and Rural
Biodegradable= 60% of total waste and Non Bio = 40% of total waste</td></tr>
<tr><td>Non - Biodegradable (TPD)</td></tr>
<tr><td colspan="4">Disposal of Municipal Waste</td></tr>
</table>

	Landfill (TPD)	70 % land fill, 10 % composted and 20% untreated of total MSW using estimates from District Environmental Plans prepared by MPCB based on primary data
	Composted (TPD)	
	Untreated (TPD)	
Bio Medical Waste	Total Generation (TPD)	Pre COVID data from Annual Report & during lockdown actual data from MPB's online BMW portal is considered
	& Treated (TPD)	

5.3.1.2 Impact Assessment on Municipal Solid waste

The lockdown has some serious consequences on the social and economic front at all levels & throughout the population of Maharashtra directly or indirectly changing the livelihood standards, lifestyle patterns & consumerism thought to be at the lowest & thereby subsequently altering municipal solid waste dynamics. The hit that commercial activities have taken pinched the eateries, malls, & associated solid waste generating potential during thr extreme restrictions of L-I & L-II; however, though the pattern quickly changed with people adapting to the new culture of COVID-19 phase, L-III allowing government to relax regulations on online delivery & online services resuming at a much higher pace than ever thereby increasing the packaging related solid waste. Though no method for estimating such characteristic change was possible, only the migration related data has been used for understanding the impact on solid waste changes at both ULB levels.

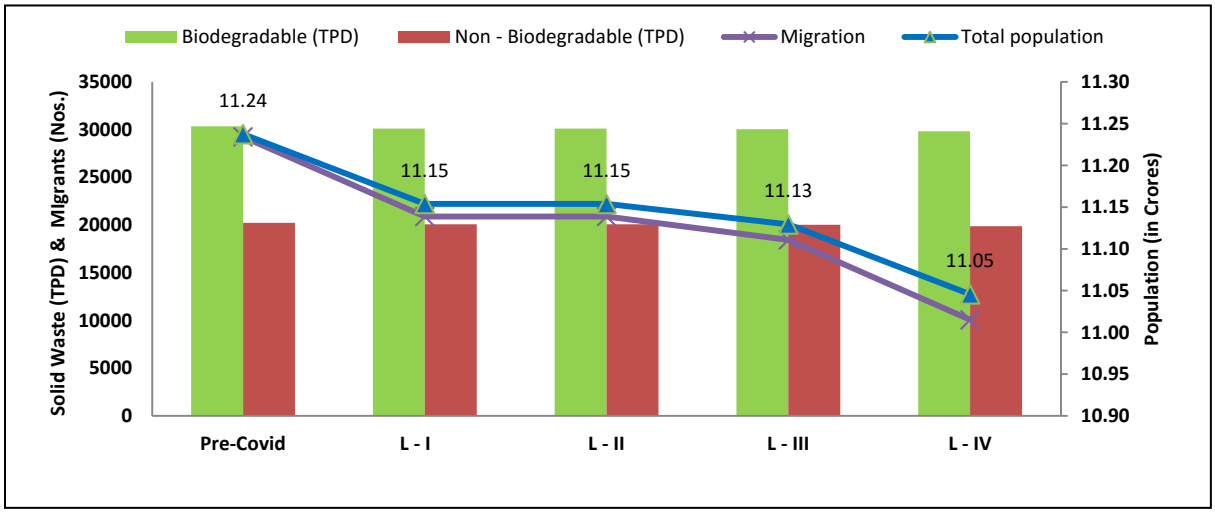

Figure 41 Effect of lockdown and migration on solid waste generation

If only migration related aspect is considered for computation of impact on SW, the average quantity of waste generated in State seems to have dropped marginally from 50,568TPD to 49,705TPD during lockdown period contemplating the migration patterns as have been discussed earlier i.e. to the tune of only 1.7% by the end of L-IV as shown in **Figure 41**.

However, it is equally important to understand & evaluate other SW sources that are surely reduced during the phases of study to a considerable extent by the limited scope of this report does not include the same. Activities such as littering have definitely reduced significantly with no people outside in

Pune Case Study

Upon survey, a Swacch spokesperson said, "Consumption has reduced drastically leading to a reduction in waste. Hotel waste, construction and demolition waste and litter waste has almost completely stopped. Sadly, recycling trade has also come to a halt and waste-pickers are not able to send waste in for recycling. We are asking citizens to clean and store dry recyclables - plastic, paper, metal and glass, till the end of the lockdown and then hand it over to waste-pickers - protecting the environment and helping the waste-pickers as well."

Head of the Solid Waste Management (SWM), Pune Municipal Corporation (PMC) said "During the Covid-19 lockdown, we have seen 500 to 550 metric tonnes of garbage less than the usual daily intake in terms of daily collection. Many residents are managing garbage disposal at their end."

public areas. Except for the shops selling essential commodities, all the shops are closed, so even the plastic generation is anticipated to be comparatively lesser thereby impacting dry waste generation significantly.

Out of the total metric tonnes of waste that is being collected during the lockdown, about 80-90% is expected to be biodegradable especially during L-I & II phases with zero construction / commercial waste. The mass generation of waste is reduced as the shopping malls, hotels and restaurants and other leisure places are closed however people are consuming equal goods at their respective places discretely. It can be assumed that reduction is observed mostly due to closing public places and population reduction due to migrants who have left the state during this time.

Extrapolation of Pune case study into other urban areas for Soild waste impacts dring COVID-19, it seems that the 500TPD waste reduction is about which is almost 30% of Pre-COVID-19 rate of generation that facilitates need for understanding the composition of waste. A primary survey of ULB's shows about 40% residential waste only whereas the other waste forms a much larger portion of total waste as presented in **Figure 42**.

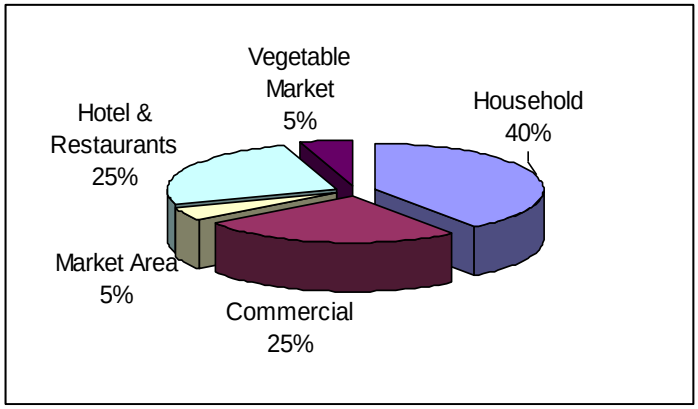

Figure 42 Sectoral share of SWM generating sources

Data Science Theory

- Residential activity Reduction @ Pre-lockdown by migrant population
- Commercial @ 5, 20, 35, 50% during L-I to L-IV
- Hotels & Restaurants @ 15, 30% permitted to deliver only during L-III to L-IV
- Vegetable markets @ 10,25,50 & 75 through phases of L-I to L-IV
- Market area @ 5, 20, 35 & 50 similar to commercial activity

Knowing that the impact of commercial activities based on composition of waste would be significant, it is essential to understand the reduced pressures on management options including the disposal paths. If all the constituent composition sectors be adjusted for solid waste generation, there seems to be almost reduction to the tune of 58% to 35% during phases from L-I to L-IV which by itself suggests equivalent pressure reduction on collection & disposal system of the State as presented in **Figure 43** translating into a huge amount of 18,000TPD lesser waste to be handled by end of L-IV.

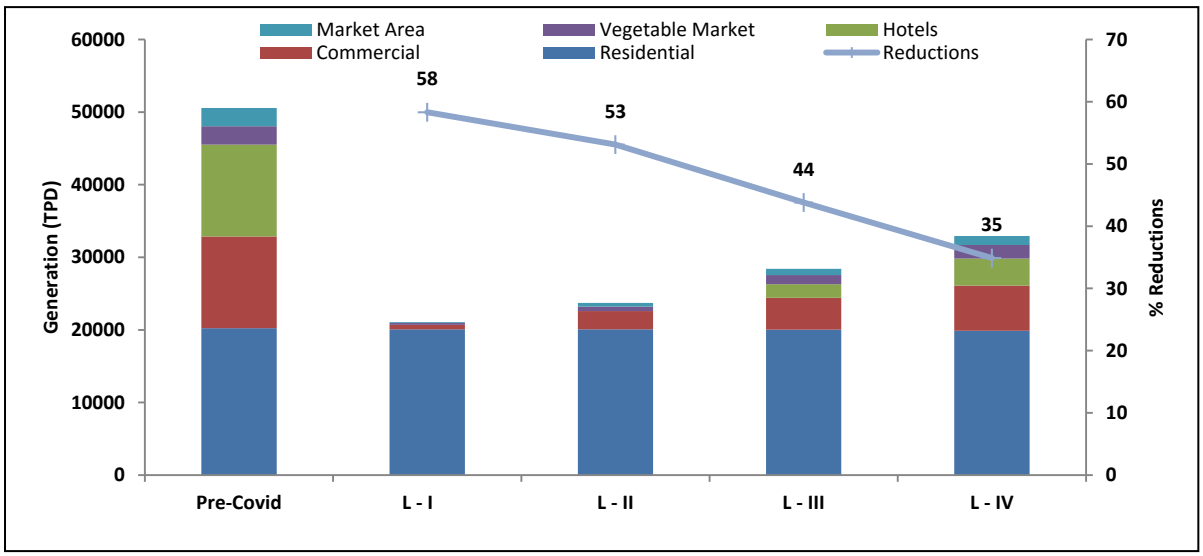

Figure 43 % reduction in waste generation from different municipal sectors due to lockdown

Not only there is a direct impact of reduction in MSW generation and handling, it also has secondary & tertiary percolating beneficial impacts due to reduced load on landfill, transportation related air pollution reduction, landfill related air pollution, impact on leachate though may be marginal & predominantly on aesthetics impacts during the entire process.

5.3.1.3 Activity Mapping for Hazardous Solid Waste

Hazardous are the wastes with properties that make them dangerous or potentially to human health or to the environment. In 2018-19 hazardous waste was generated during processing in 6,459 industries. Installation of Global Positioning System (GPS) for tracking of hazardous waste transporting vehicles has been made mandatory in the State. MPCB has authorized 182 hazardous waste transporters. Common facilities for management of hazardous waste have been set-up at four major sites, namely Taloja & Trans Thane Creek industrial areas of MIDC in Thane, Ranjangaon in Pune and Butibori in Nagpur. About 1102879.38MTA of waste was generated across Maharashtra whereas that received at CHWTSDF with various treatments facilitated are 360,548.7MTA.

5.3.1.3.1 Impact Assessment on Hazardous Waste

Information gathering from industrial units for generation of HW was impossible though attempt is still made by MPCB to inventorize & collate information directly from industries permitted during phases of lockdown. Not only that that industrial activity was restricted so was the CHWTSDF and transportation in conventional schedule thereby piling up of HW even if they were generated may be thought as a limitation to quantify the real impact. However, the best logical guesstimate is based on % of restricted industrial activity that in turn suggest about 80% reduction in generation and handling of HW overall. However the data from CHWTSDF for receipt and treatment of HW as presented in **Figure 44** shows MT/M of waste handling as compared to that from previous year in different at four CHWTSDF sites in Maharashtra. The effect of lockdown is clearly seen during April'20; wherein strict restriction on all activities was implemented quantity of HW received at Nagpur site was reduced by 93%, Navi Mumbai & Pune site showed nearly 80% reduction whereas 40% reduction was observed at Taloja site. However, during May'20, as few activities were allowed, almost equal quantities of HW were received at these sites as a result of disposing stocked HW by industries which were scheduled to be disposed during the lockdown and industries can't stock it for more than 90days as per HW handling rules along with regular generation of HW from operation.

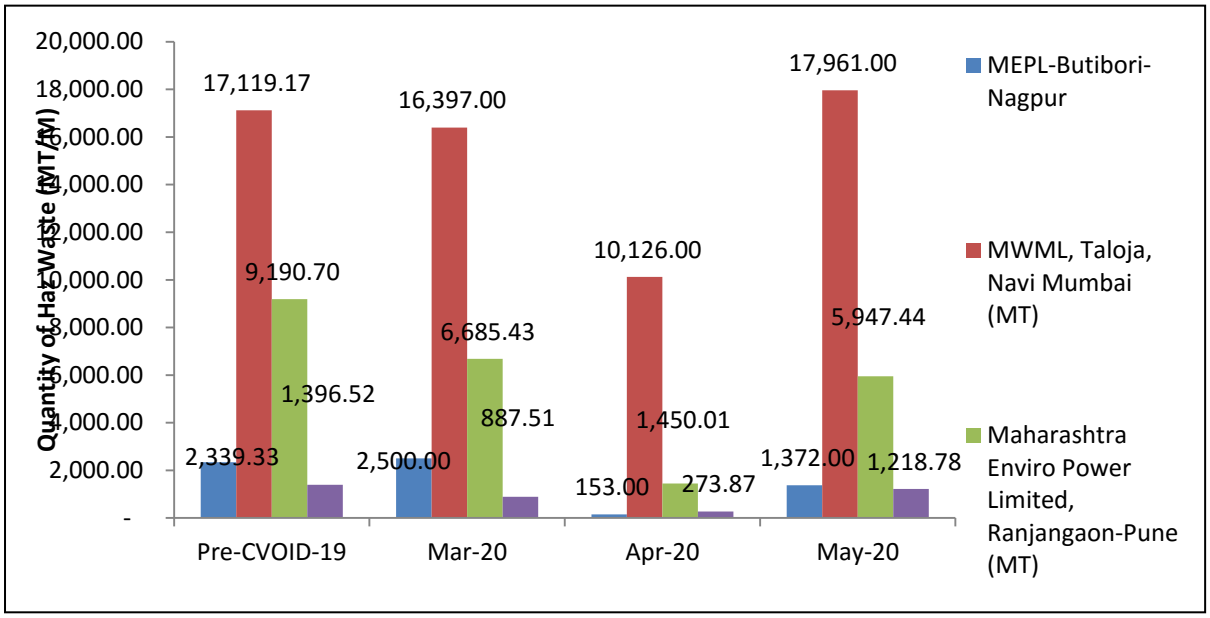

Figure 44 Effect of COVID-19 lockdown on hazardous waste generation

5.3.1.4 Activity Mapping for Bio Medical Waste

As per Bio-Medical Waste Management Rules - 2016, MPCB has started issuing authorization to Health Care Establishments (HCEs) for disposal of bio-medical waste. There are in all 60,410 HCEs under the purview of MPCB in the State upto December, 2018. The bio-medical waste generated from these HCEs is treated and disposed by 31 Common Bio-Medical Waste Treatment and Disposal Facilities; of which 29 are operating incinerations & remaining have deep burial facility. During 2019 on an average about 62.13MT bio-medical waste was treated and disposed off per day.

5.3.1.4.1 Impact Assessment on Bio Medical Waste

The COVID-19 pandemic has already had tremendous impacts on the almost all sector and thankfully in a positive way on environment including significant load reductions on solid waste management. Contrary to the other environmental attributes, COVID-19 being a health pandemic, the waste produced by hospitals is anticipated to be grown markedly in the areas most affected by the virus, and it is vital for this waste to be treated under the best health and safety conditions. Usually waste generation over space & time has marginal variations during normalcy period across the year but due to COVID-19 there seems to be marked variation. It is observed from reports all over the globe that the world will be drowning in medical waste in 2020 due to the 2019 COVID-19, and the repercussions of this glut will have a profound impact on sustainable medical waste management practices for years to come.

Initially, when the pandemic was progressing and lockdowns imposed in many countries, public authorities and municipal waste operators had to rapidly adapt their waste management systems and procedures to the situation. A summary of the trends observed amongst these practices during this period along with rise in cases of COVID-19 affected patients is provided in the infographic in **Figure 45.** An enormous rise in tons of daily BWM generation is observed by 45% from pre-COVID-19 period in Maharashtra. (i.e From 62.3 TPD to 90.6TPD).

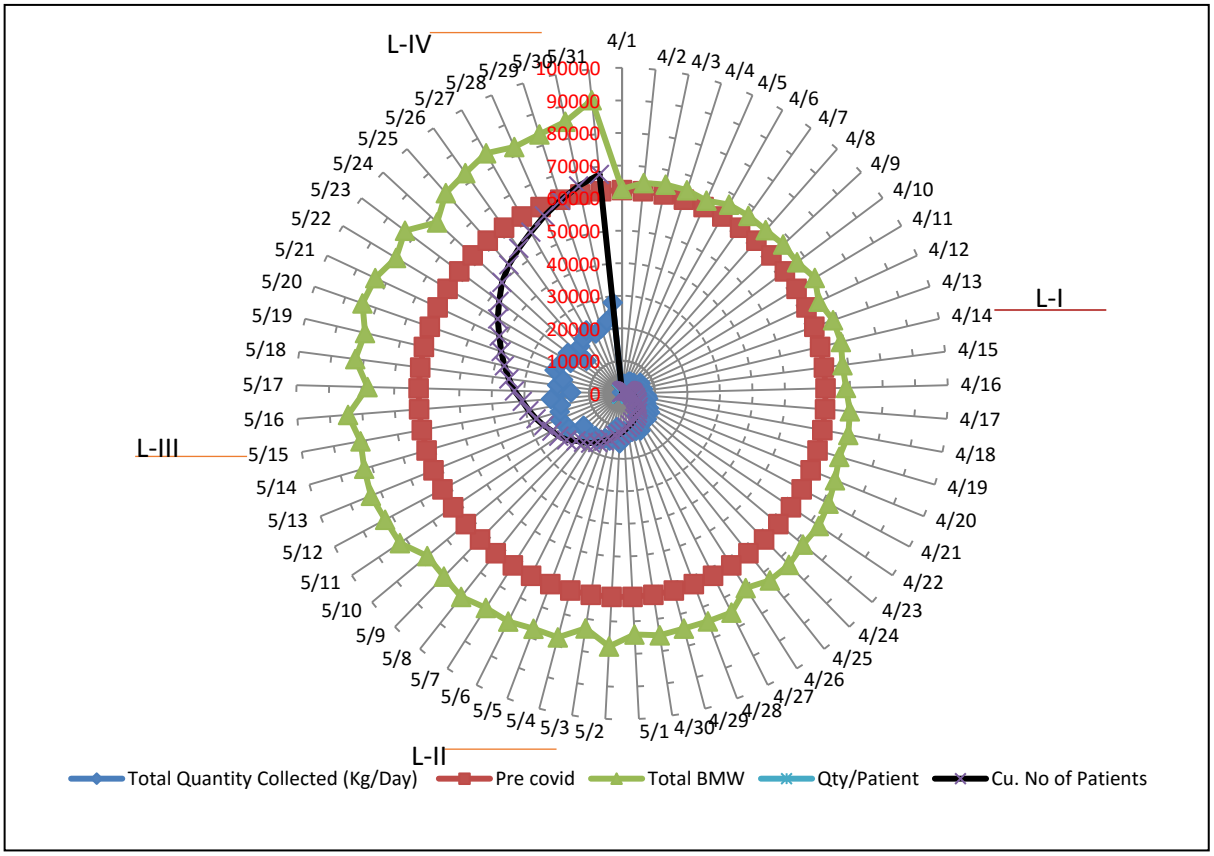

Figure 45 Effect of COVID-19 on biomedical waste generation trends with respect to COVID-19 affected patients

Believe it or not that the pace at which the COVID-19 infected patients are being identified and with the increasing spread across geospatial boundaries, & assuming that all the patients so identified are needed to be hospitalized, by the end of L-I additional 10% additional burden of BMW by 6.5TPD is generated from the daily usual generation, during L-II & L-II additional 15% & 30% by 10TPD & 20TPD respectively is generated and by the end of L-IV as number of patients were increased almost 45% additional BMW is generated leading to enormous pressures on collection and handling system. Adaption is quintessential for local bodies & administration to be able to cope up with this increasing demand of BMW management effectively.

Chapter VI
Allied & Secondary Percolating Impacts

6.0 Preamble -Allied & Secondary Percolating Impacts

The COVID-19 pandemic has changed the world in many ways. Of the several implications on humanity, the issues of health, the rapid decline of economy, shortage of medicines, sanitizers, masks, and other essentials, poverty, unemployment has undoubtedly taken centre stage and each has left a mark on the lives of people.

The manufacturing patterns, opportunities, positive impacts on several of the environmental attributes, lifestyle changes, negative impact on bio medical waste generation, and most importantly consumerism are parameters of discussion across the globe. Though recovery from this pandemic is still worked out by the world with Indian government too offering for effective measures of hand holding, COVID-19 has shown people that nature's corrective / altering mechanism can pose real challenges of our very survival.

Many allied impacts of COVID-19 that needs primary data collection and collation along with several of the secondary impacts are beyond the scope of this report however, the authors feel it extremely important to touch base on these aspects as a matter of orientation for further research. These aspects are mostly references available on various media / social platforms & are only an attempt to provide perspective to the entire issue.

6.1 Consumerism

Lifestyle related changes are the most visible aspects visible through postings of general people on social media. However, the quantification of such impacts & its extents are yet to be realistically assessed. However, as consumers pinch pennies, their reduced spending could decimate many industries while on the other hand a lucky few will benefit from increased spending in certain categories. COVID-19 has altered consumer behaviour to a great extent & thereby their lifestyle ultimately changing environmental impacts from every individual person in India & across the globe.

India still continues to be in a much air place when compared to many other countries in terms of almost all sectors analyzed by the expected spending18 for each category over the next 2 weeks i.e. up to almost L-III phase compared to usual (the Net Intent %).

6.2 Impact on Economy

Maharashtra is one of India's most prosperous, accounting for nearly 15% of the country's economy, 24% its total exports, a hub of manufacturing, finance and services sector and home to nearly 15lakh MSMEs. With Maharashtra accounting for a third of India's tally of virus cases, the severest impact is likely to be felt on the services sector which accounts for around 55-60% of the state's economy. The country's most industrialized state has the maximum number of red zones, where fewer commercial activities are allowed. At least 14 of its 36 districts are in the red zone and only six fall in the green, where full-fledged economic activities are allowed. Mumbai, the trade and commerce capital and the hub of manufacturing, accounts for over 6% of India's economy, 30% of income tax collections, 60% of customs duty and Rs 40,000crore in corporate taxes. Besides, almost 65% of Maharashtra's total revenue receipts comes from its own sources, including GST, stamps and registrations, state excise duty, sales tax and VAT. According to data available with The

1.0 [18] How COVID-19 Consumer Spending is Impacting Industries, Katie Jones April 2020, Visual Capitalist

Hindu, the revenue received by the State through non-GST sources in April in financial year 2018-19 and 2019-20 was ₹7,829.44crore and ₹8,251.2crore, respectively. However, this year, the receipts for April are barely ₹3,314.42crore. Of this, the major contribution comes from Sales Tax on fuel which is around ₹2,299.82crore. Stamp duty from registrations brought in ₹269.35crore and excise duties another ₹237.5crore. According to officials, the State was expecting the revenue around ₹3,500crore, ₹2,400crore and ₹1,200crore in April from sales tax, stamp duty and excise.

In view of the crisis, the State's Power Department has decided to reduce power tariff on an average by 7% for consumers. For the industrial and commercial consumers, the reduction in tariff would be 10-15%, while for residential consumers, it would be 5%. Further, for the next three months, industrial and commercial consumers will not have to pay fixed charges. There will be no increase in tariff for agriculture consumers, and those using power derived from solar roof sources will not have to pay any additional charges.

As per the budget presented on March 6, 2020, the State was already staring at a revenue deficit of ₹9,510.71crore. With financial activity closed down for over 40 days now and all source of revenue dried up the deficit is likely to soar[19]. State's finance department has estimated its own loss in tax revenues of about Rs 50,000crore, during the third phase of the lockdown. For the current financial year, the state's own tax revenues were budgeted at Rs 2,25,071crore. The report also quoted senior officials as saying that the losses due to the lockdown will only likely to increase.

The state has also frozen fresh recruitment till further orders. "Department secretaries have been asked to review all ongoing schemes. Only those that are unavoidable will be taken up on priority. Some others will be stayed. Others that can be avoided will be cancelled," Departments have also been barred from releasing funds to loss-making corporations for now. The government also asked the departments to stop administrative expenses at 75 per cent of the budgeted amount, and also announced restrictions on office renovation, stationery, consultancies, and rents among others. According to a report by Indian Express, the worst-hit state by the pandemic, Maharashtra, has decided to freeze any new capital works till March next to cope up with the losses incurred due to the lockdown. The state government has also ordered a slash of 67% in development (scheme) spend for 2020-21, which is the deepest ever cut in expenditure since the formation of the state.

6.3 Impact due to Migrant Movement

The issue of migrant workers was one of the most cruel and highlighted issue in this pandemic where millions were rendered unemployed and stranded without money, food and shelter, criss-crossing the country's highways to return to their villages and several meeting with accidents and deaths on their way. Unemployment has rendered a large section as directionless, leaving the social health as well as economy in shambles. Maharashtra home minister Anil Deshmukh, on Monday, said that since 1 May, at least 822 Shramik special trains from Maharashtra have taken 11.86 lakh migrant workers back to their home states and the state government has made special arrangements to facilitate the travel of stranded migrant labourers.

[19] https://www.thehindu.com/news/national/other-states/coronavirus-lockdown-chokes maharashtras-economic-lifeline/article31537687.ece

The state government is running 810 relief camps where 37,994 migrant labourers have been given refuge with food and necessities[20].

6.4 Impact on Employment

Maharashtra's unemployment rate increased 15.1% points, rising to 20.9% in Apr 2020, according to a survey conducted by the Centre for Monitoring Indian Economy (CMIE). Over a longer time period, unemployment has moved from 2.7% in Dec 2017 to its current rate.

6.5 Impact on Education System

Maharashtra government canceled all the exams from grades 1–8 to make it easier to contain the Coronavirus outbreak among school students. The students of grades 1 to 8 were directly promoted. Mumbai University canceled the examinations of its first and second-year students respectively and the education minister of Maharashtra wrote a letter to the university to cancel the examinations of its third-year students.

6.6 Impact on Transport Industry

Over 20,000 bus services of Maharashtra State Road Transport Corporation were cancelled since 11 March, which caused the organization losses of ₹3 Crore by 17 March.

The road and highway sector will see developers and toll operators incurring toll revenue losses of ₹3,450-3,700 crore during March-June, the report said. The National Highways Authority of India (NHAI) will lose ₹2,100-2,200 crore in toll taxes during this period, which has mostly been under the lockdown[21].

6.7 Impact on Aviation

Credit rating agency Crisil has estimated that the Indian aviation sector, including airlines and airports, will witness revenue losses of ₹24,000–25,000 crore, as air travel remains suspended due to the national lockdown. Airlines will be the worst-hit, contributing to more than 70% of the losses, or about ₹17,000 crore, followed by airport operators with ₹5,000-5,500 crore, and airport retailers, including retail, food and beverages and duty-free, with ₹1,700-1,800 crore, the agency said in a report. This would reverse the trend growth of roughly 11% per annum, which the industry has seen in the past ten years, making it one of the most affected sectors of the economy as per Crisil[22].

[20] https://www.livemint.com/news/india/COVID-19-19-impact-maharashtra-sends-back-11-86-lakh-migrant-workers-11591024505693.html
[21] https://www.news18.com/news/auto/aviation-sector-in-india-stares-at-rs-25000-crore-loss-due-to-COVID-19-19-crisis-crisil-2611513.html
[22] https://www.news18.com/news/auto/aviation-sector-in-india-stares-at-rs-25000-crore-loss-due-to-COVID-19-19-crisis-crisil-2611513.html

7.0 Impact Evaluation – The Conclusion

COVID-19 has resulted in about 70,000 patients being infected & unfortunately taken lives of 2300 individuals in Maharashtra[23]. Economic crisis & recession is inevitable as predicted by most of the scholars across the globe & especially State of Maharashtra being the epicenter of Indian economy contributing highest share of 14.3% towards All-India nominal GDP ranked 2nd in employing number of workers with share of 11.6%. It is only to imagine that the State that had 5cr working population with 12.3% in service industry & 16% craft & trading along with 9.6% that are not classified into specific occupations as per 2011 Census when brought to a standstill almost 50% of the populations life is directly impacted. This is surely expected to have not only primary impacts but shall extend to secondary & tertiary too.

Being Indian & thriving in the most adaptable State of India, Maharashtra, there is hope & opportunity in every scenario when looked from a positive angle even in the worst of this health pandemic. This belief & perception bought out amazingly important fact that the so called “Nature’s Correction” should be evaluated & quantified in order to be able to continue quest for sustainability during the post COVID-19 times to come.

It is this positive side during times of COVID-19 crisis that is attempted to be evaluated in the study period & the facts & figures prove the very objective & expectation of this meticulous study. The reports journeys through each of the 3 main attributes i.e. air, water & Solid waste & attempts at establishing causal-effect in observational changes in environment prima facie contemplating positive impact anticipated due to restricted activities across population and sectors. Conclusively enough it can be stated that the slowdown / restrictions of activities has had direct positive impact on almost all the essential environmental attributes to a great extent except for the biomedical waste parameter, COVID-19 being recognized as health pandemic. Perception of people towards betterment of environmental conditions across the State is quite well featured in most of the social & other media platforms.

This subjective perception of people witnessing clean air, water & land is objectified through this report not only as a research orientation but also to provide insights into possible & probable apportionment of causal effect of all such activities that are known to impact a particular environmental attribute. It shall be borne in mind that all the data are obtained from reliable sources in the government especially MPCB & some cleaning of data has also been carried out with utmost care to retain all variables intact. Many of the calculations are based on assumptions that are specifically & clearly mentioned for the readers to be able to fix their confidence level in final results & the authors of the report nowhere attempts to draw credit for the massive & exemplary works published simultaneously acknowledging due credit for citations of same.

Knowing fully that the population changes have occurred only due to migration to & fro from Maharashtra, it has been affected only post L-III phase finally reducing it by 1.7% only though it seems that the difficult path to migrate during COVID-19 imposed regulations is limited to 65% with predicted 10 Lakh people waiting to finally reach their native locations.

The thorough surrogate & assumptions based analysis of changes in activities perceived to govern quality of environmental attributes suggests notional act of environmental reset to a considerable extent most effectively witnessed in terms of air environment with only about 2362 industries permitted during L-I & finally by end of L-IV 83% of them operational as assessed from the database of MPCB. This in turn required only 64.4% out of the total 65

[23] COVID-19 Monitoring Dashboard by Public Health Department , Government of Maharashtra Science & Knowledge Partners

Lakh working population in 92,000 odd industries (as per MPCB online registered database considered as Pre- COVID-19 period baseline) to be retained on job by end of L-IV.

The activity in industries surely has taken the hit that is directly reflected with the reduction in fuel consumption (computed from already granted Consent database of these industries @ MPCB) from 9.5Lakh TPD by about 80% in L-I up to 53.8% by L-IV that in turn reflects an average reduction to extent of 83% in PM_{10} & 90% gases (SO_2, NOx & CO) during L-I further proving to be effectively 64% & 73% for PM_{10} & gases respectively by end of L-IV.

Another important & major point source emission are the Thermal Power Plants in Maharashtra generating 21,176MWh electricity using coal @ 3.55Lakh TPD during normalcy times Pre- COVID-19. The emissions in range of 1000TPD of PM_{10} whereas 1100TPD of SO_2 & 600TPD of NOx in usual times are reduced by 27, 24, 14.7 & 10.7% during phase of L-I to L-IV equivalent to the reduction in coal use to the same extent in these phases.

Over all the point sources account for about 5,629TPD of PM_{10} & 22,656TPD for gases which by the virtue of restricted activities shows reductions to the tune of approximately 56% load of PM_{10} & average 81% load of gases during L-I finally gaining momentum in activity based emissions which still remains at 34% reduced status for PM_{10} & 60% average for gases.

Line source however shows absolutely remarkable impact with almost the entire transportation sector bought to a standstill except for the essential vehicles movement. It is breath taking to know that 472cr km/day is travelled by the vehicles during business as usual (Pre- COVID-19 times) on the road network of about 3 Lakh km that the State maintains. However this enormous road activity not only has direct tail pipe emissions of about 667TPD but also lead to re suspension of dust (accounted as Re-suspended PM_{10}) that accounts to 4962TPD i.e. about 8 times higher than the tail pipe emissions especially due to accounting of the unpaved road dust in rural areas & the equivalent vehicle movement there. Subsequent imposition of limitations on travel & transport resulted in marked emissions reductions to the tune of 5%, 22%, 24% & 23% during the L-I to L-IV phases.

Area sources too are one of the factors accountable for the overall ambient air quality thereby the load from various hotels, bakeries, street vendors & construction activities are computed for even though they are extremely scattered emitters. Out of the 7,119TPD of PM_{10} emitted along with 5,800TPD of gases from this sector during the business as usual going, reductions to the tune of almost 98% was observed during the L-I & with time the very limited activities gained momentum still with 86% reductions in PM_{10} & about 45% in gases by the end of L-IV. Vehicles has been one of the highest contributors to PM_{10} amongst the area sources whereas CO accounts for the maximum share amongst gases load mostly due to high emission factor related to uncontrolled / incomplete combustion of low quality / adulterated and mixture of fuels.

Thereby, computing load of pollutants for entire Maharashtra, it seems there the 1st phase of lockdown L-I witnesses about 86% subsequently with activities & life coping up with the COVID-19 event, L-II showing 73%, L-III with 64 & finally L-IV with 58% reductions in overall emissions load.

Activity or load calculations may not seem to be a direct indicator of changes in the ambient air quality nor is it that simple to convert these emissions load in to concentration of pollutants in the ambient air since dispersal of pollutants in the air is influenced by meteorological conditions in addition to the load. However, emissions inventory presents a picture & indications of possible reductions that may be responsive to such emission load even if not linearly.

MPCB with their effective and AAQMS gathered online data at 22 locations represented as 24hr average revealed the fact that during the pre- COVID-19 period air quality in terms of all parameters drastically shows consistent reductions to the tune of 60% during entire phase of lockdown. Additionally, concentration of PM_{10} at 21 locations reduced by average 55% whereas that of SO_2 & NOx by 30 & 10% respectively. The results are in congruence with the emission load reductions so stated. In terms of AQI all stations are resulted into Satisfactory Criteria.

On the other hand, Water being the prime source of life & activities also shows marked variations not only in its consumption but also waste generation potential across the lockdown phases. The rivers & saline basins including nallahs that are connected to some of them of monitored at 250 locations under NWMP & SWMP of MPCB were compared at 125 locations FY April 2019 & 2020. The enhancement in quality is evident for all of the 6 river basins, showing changes in water quality that in terms of BOD are better at 84% of locations whereas for COD at 65% of the locations (viz. Tapi, Godavari, west flowing rivers & Nallah basins) whereas the other 2 River basins shows improvement at 30% locations. pH of water at all locations was observed to be varying in the range of 7-9 for both April'2019 & April'2020 period & DO is proportionally increased wherever the organic contents are observed to be lowered.

The observed improvement in water quality can be very well correlated with the limited activity wherein 1656 tons of BOD load was avoided in the phases of lockdown, of which avoidance amounted to 75% in rivers, 15% in seas & 10% on land (with variations over each of the phases). Such disposal pathways are accommodated using spatial distribution of industrial & domestic population in areas of river & coastal nearness. Avoidance of load was highest from industrial sector which is obvious whereas domestic sector though contributed very small % (up to 3.1% by end of L-IV) in absolute BOD load it amounted to about 1,165 tons of BOD translating into 25-75% concentration reduction of organic matter whereas 10-35% increase in DO concentration.

Urbanization, affluence & technology have led to ever increasing trend of waste generation. Maharashtra with the highest share of GDP amongst Indian states is not even more prone to such higher variations in waste as reflected with the total waste generation of about 50,000 tons/day in business as usual scenario. Migration of almost 65% population (i.e. about i.e. about 19 Lakhs), limited industrial work force & the extremely restricted commercial, hotels & restaurants as well as market place activities rendered a reduced load on SWM to the tune of 58% during the L-I & L-II whereas 44% & 35% during the subsequent L-III & L-IV phases ultimately reducing massive pressure on the SWM system.

Similarly hazardous waste generation due to restricted industrial activity reduced pressures on handling of it by average 75% though it needs to be considered that this is a short-time impact.

The only contrary negative impact on environmental attributes whereby the pandemic has massively created huge demand for revisiting system is of biomedical waste management. The increase number of COVID-19 patients reaching almost 70,000 by 31st May of 2020 the BMW generation (in worst case scenario of all patients being hospitalized) to the tune of computed 90.6TPD seems to have almost increased by 45% from the average 62.5TPD quantity (during Pre-COVID-19 times); thereby posing challenge to the managers, transporters as well as facility handlers.

Conclusively, Maharashtra State seems to have witnessed the environmental betterment to the tune of about 90-50% emissions load reduction of PM_{10} whereas 85-60% of gaseous load during L-I to L-IV phases of lockdown translating into approximately 60% concentration improvements averaged across all of the 22 monitored locations. River water quality has

improved at more than 84% & 65% for BOD & COD in Tapi, Godavari, west flowing rivers & Nallah basins whereas the other 2 River basins shows improvement at 30% locations. With respect to concentrations of monitored parameters for water quality, ample with evidence from monitored data is available that the lockdown BOD & COD parameters enhanced by 25-75% concentration reduction of organic matter whereas 10-35% increase in DO concentration needless to mention the 50-75% reductions in Nitrates & Fecal Coliforms concentration as compared to the April 2019 data. Residential solid waste was the only major contributor towards challenges in SWM in the State whereas the total shutdown of commercial activities & restaurants as well as limited industrial activities augmented with migration though may have varied spatial distribution, have definitely reduced pressures on SWM systems ranging from 58% during L-I to 35% by end of L-IV. The only negative impact of COVID-19 as anticipated is found on the biomedical waste generation with an expected rate of doubling of wastes by end of L-IV.

Nevertheless, many of the percolating impacts that may be associated further with environmental attributes such as changing patterns of consumerism, lifestyle, work culture, travel & transport it is equally important that this natures alarm of corrective attenuation be understood & anthropogenic sources be controlled effectively placing strategic environmental management systems well in advance to be able to sustain the so felt "**correction**".

Ultimately it's the virus that sets the timeline..!

Annexure I – Emission Factors considered for calculations

Source	Reference	Emission Factor			
Point Sources (Industrial Stacks)					
Fuel Type		**PM_{10}**	**SO_2**	**NOx**	**CO**
Coal (kg/kg)	USEPA - AP:42, External Combustion sources, Bituminous and sub bituminous coal combustion **Table No.1.1-3**	1.31E-03	8.55E-03	9.90E-03	2.25E-04
LDO (kg/kg)	USEPA - AP:42, External Combustion sources, Gasoline and diesel industrial engines **Table No.3.3-1**	4.32E-04	3.07E-02	4.32E-03	1.08E-03
FO (kg/kg)	USEPA - AP:42, External Combustion sources, Fuel oil combustion, **Table No.1.1-3**	1.08E-02	6.07E-02	6.59E-02	2.10E-03
CNG / PNG / NG (kg/kg)	USEPA - AP:42, External Combustion sources, Natural gas combustion, **Table No.1.4-2**	8.51E-05	0.00E+00	5.60E-04	9.41E-04
HSD / Diesel (kg/kg)	USEPA - AP:42, External Combustion sources, Gasoline and diesel industrial engines **Table No.3.3-1**	9.00E-04	1.25E-03	1.88E-02	1.88E-02
Briquette (kg/kg)	USEPA - AP:42, External Combustion sources, Charcoal, **Table No.10.7-1**	2.00E-04	-	-	-
Bagasse (kg/kg)	USEPA - AP:42, External Combustion sources, Bagasse Combustion in sugar mills **Table No.1.8-1**	3.02E-03		2.67E-03	
Wood (kg/kg)	USEPA - AP:42, External Combustion sources, Wood residue combustion in boiler, **Table No.1.6-1**	2.47E-03	2.06E-04	4.03E-03	4.94E-03
LPG (kg/kg)	USEPA - AP:42, External Combustion sources, Liquefied Petroleum Gas Combustion, **Table No.1.1-5**	6.11E-05	4.59E-07	3.97E-03	2.29E-03
Thermal Power Plant					
		PM_{10}	**SO_2**	**NOx**	**CO**
Coal (kg/kg)	USEPA - AP:42, External Combustion sources, Bituminous and sub bituminous coal combustion **Table No.1.1-3**	1.31E-03	8.55E-03	9.90E-03	2.25E-04
Area Sources					
Hotels, Bakeries & Street Vendors					
Fuel		**PM_{10}**	**SO_2**	**NOx**	**CO**
LPG (gm/kg)		2.1	0.4	1.8	0.252
Wood (gm/kg)		15.3	0.2	1.4	115.4
Coal (gm/kg)		20.0	13.3	3.99	24.92

Source	Reference	Emission Factor			
Kerosene (gm/l)		1.95	4.0	2.5	62.0
Construction	ARB section 7-7 - (630-624-5400-000) Building Construction-Commercial dust	PM_{10} - 0.11 tons of PM_{10} / Acre-month It is assumed that watering techniques are used during construction)			
Fugitive Sources					
Resuspended Dust	U.S. EPA AP-42, Section 13.2.1, March 1993. However, there are some other variables that are accounted for by using engineering estimates and sample surveys as follows: For weight (W) - Engineering estimate for Pune vehicle fleet For rainy days - Pune average 10 year meteorological data from airport Silt Loading have been actually calculated for Mumbai roads and applied in this case	***For Paved Road Dust*** $E = k (sL/2)^{0.65} (W/3)^{1.5} (1-P/4N) =$ 0.9165g/vkt E = particulate emission factor (having units matching the units of k) k = particle size multiplier for particle size range and units of interest sL = road surface silt loading (grams per square meter) (g/m^2) W = average weight (tons) of the vehicles traveling on the road P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly) ***For Unpaved Road Dust*** E = [(K (S/12)^0.8 (w/3)^0.4) /(M/0.2)^0.3] *(365-p) /365 = 1.57 g/vkt E = particulate emission factor (having units matching the units of k) k = particle size multiplier for particle size range and units of interest sL = road surface silt loading (grams per square meter) (g/m^2) W = average weight (tons) of the vehicles traveling on the road P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly)			

Sector	*Reference – ARAI, 2007*

Transportation

EMISSION FACTORS FOR CO WITH REFERENCE TO VINTAGE (GM/KM)

Age	2W	3W				4W				LCV
	P	P	D	CNG	LPG	P	D	CNG	LPG	D
5 yrs	0.4	1.72	0.41	1.29	1.29	0.84	0.06	0.85	0.35	3.66
10 yrs	1.65	1.67	2.09	0.845	1.7	2.74	0.3	0.85	2.72	3.66
15 yrs	1.65	3.15	3.15	4.39	4.39	4.825	0.3	0.6	0.85	3

EMISSION FACTORS FOR NOX WITH REFERENCE TO VINTAGE (GM/KM)

Age	2W	3W				4W				LCV
	P	P	D	CNG	LPG	P	D	CNG	LPG	D
5 yrs	0.25	0.3	0.3	0.08	0.08	0.09	0.28	0.53	0.53	2.12
10 yrs	0.27	0.3	0.69	0.345	0.04	0.21	0.49	0.53	0.2	2.12
15 yrs	0.27	0.345	0.51	1.29	1.29	0.645	0.49	0.01	0.35	2.48

EMISSION FACTORS FOR PM_{10} WITH REFERENCE TO VINTAGE FOR (GM/KM)

Age	2W	3W				4W				LCV
	P	P	D	CNG	LPG	P	D	CNG	LPG	D
5 yrs	0.015	0.118	0.091	0.091	0.015	0.002	0.015	0.001	0.001	0.475
10 yrs	0.035	0.118	0.347	0.067	0.015	0.006	0.06	0.001	0.001	0.475
15 yrs	0.23	0.35	0.11	0.721	0.35	0.0195	0.06	0.002	0.002	0.655

EMISSION FACTORS FOR PM_{10} WITH REFERENCE TO VINTAGE FOR (GM/KM)

EF	2W 2S	2W 4S	3W 2S	3W 4S	4W G	4W D	HDD-LS	HDD-HS
g/km						10.3	2.5	25.4

NOTE: 2W – Two Wheeler, 3W – Auto Rickshaw, 4W – Cars/Jeep/ Taxis, LCV – Light Commercial Vehicles/ 3/4 Axle, P – Petrol, D - Diesel

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