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TREND EDITORIAL

Proposed city-specific interim targets for India based on WHO air quality guidelines 2021

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Abstract

The World HealthOrganization has proposed the ambient air quality guidelines 2021. Theuniqueness of the guidelines of the World Health Organization — air qualityguidelines 2021 — is the inclusion of interim targets. Higher levels of air pollutantsincluding $PM_{2.5}$ for ambient air in India were recorded in recenttimes, and its association with respiratory and cardiovascular health risks wasevidenced in the recent literature. To achieve the ambient air qualitystandards in India as per the World Health Organization — air quality guidelines,there is a need for interim targets in the future National Ambient Air QualityStandards to be proposed in India. These interim targets may be proposed fornon-attainment/attainment cities based on the $PM_{2.5}$ concentrationlevels to achieve a realistic target of recommended levels in a graded manner andthereby minimize air pollution in the specific location.

Keywords Air quality guidelines · Interim targets · Non-attainment cities · PM2.5 · India

Introduction

The World Health Organization (WHO) has revised its air quality guidelines (AQG) in September 2021 (WHO 2021a, b). The earlier revision of guidelines by WHO was done in the year 2005. Many countries including India could not often maintain the levels set by WHO, and the result was severe air pollution in their major cities. Air pollution has become the second risk factor for morbidity and mortality related to respiratory diseases in India as per the Global Burden of Disease study (India State-Level Disease Burden Initiative Collaborators (Dandona et al. 2017). Although National Ambient Air Quality Standards (NAAQS) were set by Central Pollution Control Board (CPCB) in 2009, the major cities could often not maintain the air pollution loads below the recommended levels of NAAQS in India, especially for $PM_{2.5}$. The chemical characterization of $PM_{2.5}$ has evidenced the concentration of heavy metals, volatile organic compounds, and other toxicants. Hence, the exposure of $PM_{2.5}$ including their carcinogenic property as evidenced in the IARC document as 1A-high-risk group can pose human health problems including cancer (IARC 2013). Considering the health risks of $PM_{2.5}$ and evidence of lung function decline in the Indian population (Kesavachandran et al. 2013), there is a need for a reduction in $PM_{2.5}$ emissions in ambient air, especially in cities with severe air pollution in India.

WHO has proposed interim targets which can be considered as progressive stages towards the attainment of reduction in air pollution, and these targets can be more useful in areas with high air pollution cities (WHO 2021a, b). Globally, there is a disparity in the attainment of NAAQS standards especially in developing economies. Interim targets were proposed by WHO for AQG during 2005 which was designed as an alternate protocol of guidance towards the attainment of the final target of recommended levels for each ambient air pollutant through different interim stages. The abatement measures may be proposed for each non-attainment/attainment city based on the interim target. Most of the countries with NAAQS regulation follow interim targets

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for the attainment of recommended air quality standards (Joss et al. 2017; WHO 2021a, b). The proposed interim targets can be considered as a vital tool towards attainment to achieve AQG levels.

Effectiveness, efficiency, and feasibility of interim targets

The WHO-AQG has reduced the recommended limits of air pollution parameters from the previous AQG levels. The decline in the levels of AQG can lead to reduced air pollution and minimize the health risks and enhance the mitigation efforts for climate change. Although the proposed new AQG is recommended for all the countries, WHO has suggested that it will be difficult for many countries like India to follow the recommended levels due to high air pollution levels. Hence, WHO has proposed several interim targets or ambition targets.

These interim targets will be able to facilitate gradual improvement in the air quality at each location in a stepwise manner. It was proposed by WHO that during the determination of the stepwise or gradual manner, it should be meaningful and feasible and based on relevant evidence of air pollution data for each country. Hence, WHO has proposed several interim targets or ambition targets. This will facilitate for gradual improvement in the air quality at each location based on interim targets (WHO 2021a, b).

Study protocol followed

The online monitoring system of CPCB for air quality (Ref: CPCB online ambient air portal, CPCB | Central Pollution Control Board access date:07/02/22) data was retrieved for the analysis. The year 2019 ambient air quality monitor data for $PM_{2.5}$ was used for the analysis. The data from January to March 2019 (pre-monsoon) and October to December 2019 (post-monsoon) was pooled for the analysis of how many days the $PM_{2.5}$ crossed the permissible limit at each sampling station in India. The 2019-year data was taken to nullify the effect of COVID pandemic and lockdown days, which may bias the real ambient air condition in each region. The inclusion of the selection of each sampling location for a corresponding interim target is based on the $PM_{2.5}$ concentration during the assessment period. A total of 290 ambient air monitoring stations was available across the country in 2019 during the access period. Out of which, 111 was not showing any data during the year 2019. The data was available for 179 stations only and out of which data was available for all days in a month for 63 stations. After the above exclusion/inclusion criteria followed in the study, data from 63 stations were selected for the analysis, and corresponding interim targets were proposed as per WHO air quality guidelines 2021. The study suggests a graded and realistic approach for the attainment of recommended levels of $PM_{2.5}$ using interim targets set for non-attainment/attainment cities in India. These graded targets set for reduction of air pollution will be useful in the reduction of respiratory and cardiovascular health risks.

$PM_{2.5}$ in Indian cities and its proposed interim targets

The presentation in Fig. 1 showed the interim targets set by WHO for $PM_{2.5}$ (WHO 2021a, b) and compared with existing NAAQs norms in India set by CPCB (CPCB 2009). NAAQS proposed in India for each pollutant are in the different interim targets of WHO-AQG. A map showing the locations of all monitoring stations included in the

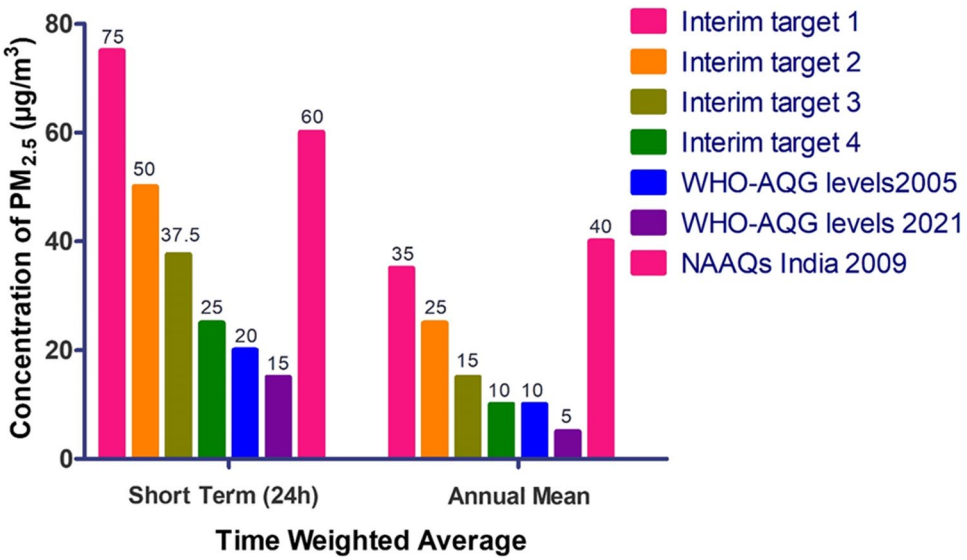

Fig. 1 Interim targets set by WHO for $PM_{2.5}$ and NAAQS for India

study is shown in Fig. 2. The proposed interim targets to be attained for each city as per ambient air monitoring stations for the $PM_{2.5}$ concentration recorded in the year 2019 are shown in Table 1. The details of cities corresponding to each interim target is represented in Supplementary file-Annexure-1.

Table 1 shows details of interim targets for the states based on their $PM_{2.5}$ concentration in ambient air. The worst scenario of $PM_{2.5}$ pollution was observed in the following states, viz., Delhi, Gujarat, Uttar Pradesh, West Bengal, and Rajasthan based on their $PM_{2.5}$ concentration above the permissible limits of 60 μg/m^3 for more than

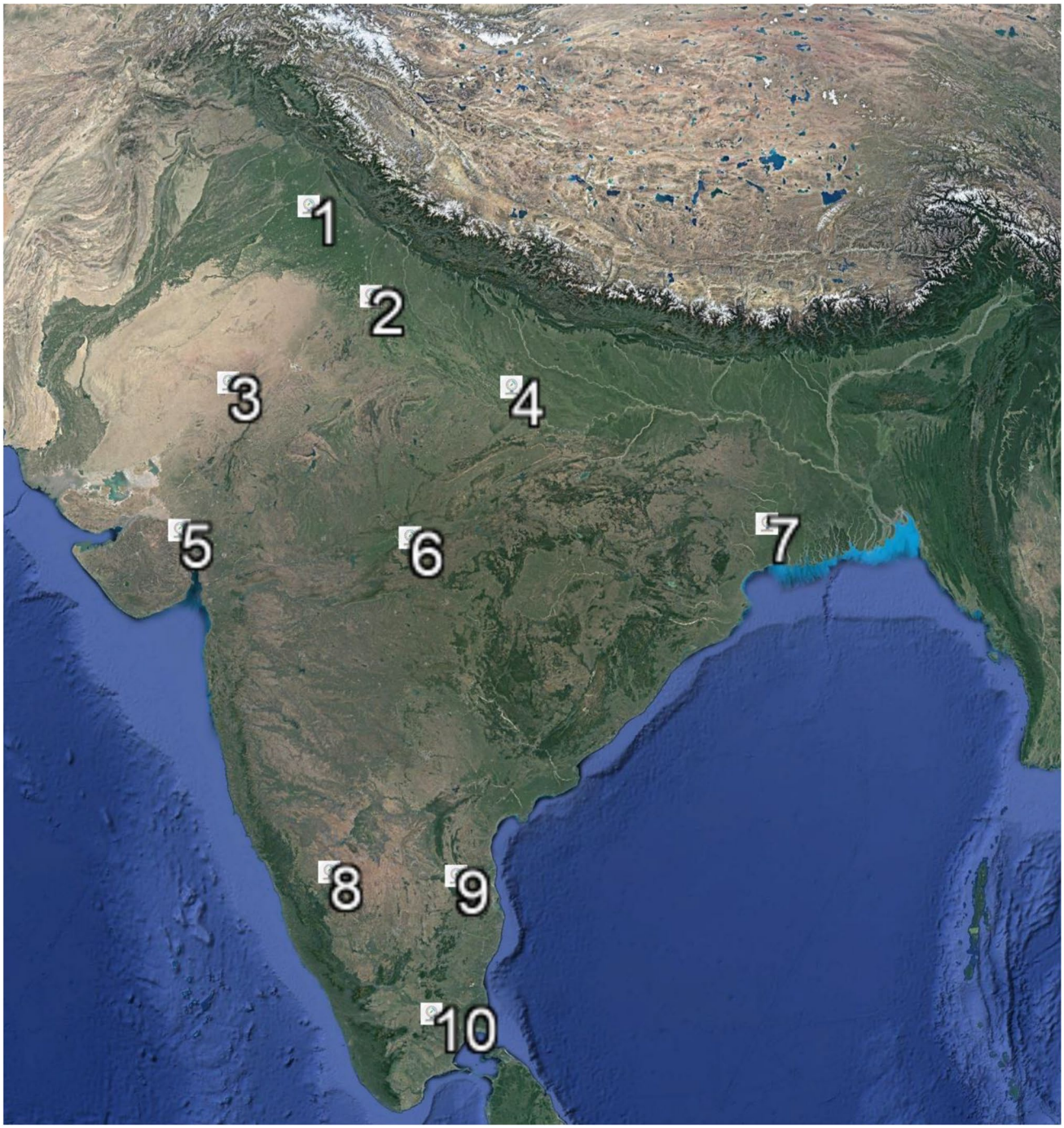

Fig. 2 Geographical locations of 63 ambient air monitoring stations are located. **1**. Punjab (7 stations), **2**. Delhi (23 stations), **3**. Rajasthan (10 stations), **4**. Uttar Pradesh (6 stations), **5**.Gujarat (1 station), **6**. Madhya Pradesh (7 stations), **7**. WestBengal (4 stations), **8**. Karnataka (2 stations), **9**. AndhraPradesh (2 stations), **10**. Tamil Nadu (1 station)

Table 1 Proposed interim targets based on WHO-AQG for $PM_{2.5}$ and probable attainment of cities

Proposed targets for NAAQS in India $PM_{2.5}$ (μg/m^3)	Concentration of $PM_{2.5}$ (WHO) (μg/m^3)	Ambition level for NAAQS in India based on WHO-AQG	Concentration of $PM_{2.5}$ (μg/m^3)	Percentage of days, $PM_{2.5}$ concentration (μg/m^3) crossed the NAAQS limits for respective city
Interim target 1	75	High	> 60	**60% and above**: 37 (Delhi, 23; Gujarat, 1; Uttar Pradesh, 6; West Bengal, 4; Rajasthan, 3) **40–59%**:8 (Madhya Pradesh, 3; Punjab, 3; Rajasthan, 2) **20–39%**: 10 (Andhra Pradesh, 1; Madhya Pradesh, 2; Punjab, 3; Rajasthan, 3; Tamil Nadu, 1) **1–20%**: 8 (Andhra Pradesh, 1; Karnataka, 2; Madhya Pradesh, 2; Punjab, 1; Rajasthan, 2)
Interim target 2	50	Moderate	25 to ≤ 60	**60% and above**: 10 (Rajasthan, 5; Madhya Pradesh, 3; Karnataka, 2) **40–59%**: 13 (Andhra Pradesh, 1; Madhya Pradesh, 3; Punjab, 6; Rajasthan, 2; Tamil Nadu, 1) **20–39%**: 11 (Andhra Pradesh, 1; Gujarat, 1; Madhya Pradesh, 1; Punjab, 1; Rajasthan, 2; Uttar Pradesh, 2; West Bengal, 3) **1–19%**: 29 (Delhi, 23; Rajasthan, 1; Uttar Pradesh, 4; West Bengal, 1)
Interim target 3	37.5			
Interim target 4	25	Medium	> 15 to ≤ 25	**60% and above**: Nil **40–59%**: Nil **20–39%**: 2 (Andhra Pradesh, 1; Punjab, 1) **0–19%**: 61 (Andhra Pradesh, 1; Delhi, 23; Gujarat, 1; Karnataka, 2; Madhya Pradesh, 7; Punjab, 6; Rajasthan, 10; Tamil Nadu, 1; Uttar Pradesh, 6; West Bengal, 4)
AQG-WHO	15	Low	≤ 15	**60% and above**: Nil **40–59%**: Nil **20–39%**: **1** (Andhra Pradesh, 1) **0–19%**: **62** (Andhra Pradesh, 1; Delhi, 23; Gujarat, 1; Karnataka, 2; Madhya Pradesh, 7; Punjab, 7; Rajasthan, 10; Tamil Nadu, 1; Uttar Pradesh, 6; West Bengal, 4)

60% of days. These states were classified in the interim target 1, i.e., 75 μg/m^3, as their first target to be achieved. Maharashtra, Punjab, and Rajasthan are the next most polluted states, followed by Andhra Pradesh and Karnataka. Some of the monitoring stations at Rajasthan, Gujarat, Madhya Pradesh, Punjab, Karnataka, Uttar Pradesh, West Bengal, and Delhi showed 25–60 μg/m^3 during the year 2019.

Considering the wide range of concentration differences between the different air monitoring stations, there is a need for a detailed investigation of local sources responsible for $PM_{2.5}$ in each higher concentration observed station. The commercial, industrial, burning of waste, agricultural residues and micrometeorological factors in each location may be studied in detail especially in the locations near to air monitoring stations for better mitigation strategies. A grade-based system like interim targets set for each city based on their $PM_{2.5}$ concentration may be a better option to reduce the concentration levels and better management practices.

The interim target 4, i.e., > 15 to ≤ 25 μg/m^3, was not achieved in any city in India for more than 60% of days in 2019. Similarly, WHO AQI norms of 15 μg/m^3 were also not achieved by any cities in India for more than 60% of days during our analysis of online ambient air monitoring data. Therefore, it is not feasible to propose a figure like 15 μg/m^3 for $PM_{2.5}$ limits in the future for NAAQS guidelines. Based on this above observation, a graded system like interim targets may be a suitable solution for the permissible limits in NAAQS in India compared to non-acheivable single target. A city-specific interim target will be a more practical solution than the country-specific interim target, as the present analysis has revealed the highly polluted cities concentrated mostly on the northern and western part of India compared to the southern and eastern part.

The National Clean Air Program (NCAP) 2019 has proposed the need for the attainment of air quality standards at all locations in India within the prescribed time frame (NCAP 2021). To achieve the targets of NAAQS, a time-bound action plan is required specific for non-attainment and attainment cities in India (NCAP 2021). Therefore, the future NAAQS guidelines may focus on specific prescribed limits for non-attainment and attainment cities in India. This approach to minimizing the $PM_{2.5}$ emissions through a phase-out manner using the interim targets will function as a rider for non-attainment/attainment cities to achieve time-bound intervention strategies.

A similar trend was observed for 24 hour ambient air monitoring stations located at different geographical regions in India from 1st January 2021 to 27 September 2021 (Sen et al. 2021). There are 18 non-attainment cities in Maharashtra and 15 in Uttar Pradesh in terms of ambient air pollution levels as per an earlier report (Ganguly et al. 2020). Transport, road dust, domestic cooking, and heating are considered as major sources of air pollution as per the air quality management studies undertaken in 102 cities in India (Ganguly et al. 2020).

Need for categories and interim targets in the NAAQS guidelines

The challenge of interim targets set by WHO-AQI can be considered as an opportunity for high emission of $PM_{2.5}$ recorded cities in India to limit their sources of $PM_{2.5}$ pollution. The proposed ambition level of attainment for $PM_{2.5}$ in Indian cities as per the AQG of WHO was derived based on the % of days with different ambient air concentration levels of $PM_{2.5}$ for each city within the corresponding interim targets. As per the NCAP report published in 2019, there are 132 non-attainment/million-plus cities in India (NCAP 2021) for $PM_{2.5}$ levels proposed by NAAQS in 2009. In the existing NAAQS guidelines, there is no provision for category-wise recommended limits for $PM_{2.5}$ in attainment or non-attainment cities. If the NAAQS recommended limits for $PM_{2.5}$ are reduced in the future NAAQS guidelines as in the case of WHO-AQI, 2021, it will be difficult to achieve the targets by any of the non-attainment cities in India. Therefore, the future NAAQS guidelines may consider recommended levels for $PM_{2.5}$ in non-attainment cities and attainment cities as specific categories and propose interim targets. In this approach, the control of emissions of $PM_{2.5}$ limits may be set at an initial stage (interim target 1) and, once it is attained, may look forward to the next achievable targets (interim targets 2, 3, 4) in a time-bound manner, rather than fix a recommended levels for $PM_{2.5}$ in non-attainment cities/attainment cities.

During the COVID lockdown period, it was widely observed that air pollution levels in India have dropped down considerably due to limited transportation and industrial activity. An observational study conducted during the COVID period in India has shown a 75% decline in $PM_{2.5}$ levels in the post-covid period compared to the pre-covid period (24 March 2020 to 24 April 2020) (Leigh et al. 2021); percentage levels dropped to less than 8% when the meteorological parameters were factored into the observed 75% decline reported for post-covid period (Leigh et al. 2021). Therefore, we have included the 2019 data of $PM_{2.5}$ for the analysis to eliminate the discrepancies in the data during COVID lockdown period from 2020-2021.

The interim targets as proposed by WHO and identified non-attainment/attainment city-specific ambition targets can be adopted by policyholders for revised NAAQS guidelines in India, considering the achievable realistic value, for different regions based on the present scenario of $PM_{2.5}$ pollution levels. This will enable each non-attainment/attainment city to develop management strategies to attain the recommended levels based on interim targets and ambition levels in a graded manner from the present status of ambient air pollution for $PM_{2.5}$.

Ambient $PM_{2.5}$ pollution — the need for NAAQS update?

There is a wide range of low to high levels of $PM_{2.5}$ emissions reported in different cities in India since the last updated NAAQS guidelines in 2009. Several drastic changes in the meteorological factors, industrial activities, transport emissions, agriculture waste burning emissions, and municipal waste emissions have occurred since the last proposed NAAQS guidelines. Hence, there is a need to revise the present NAAQS guidelines.

The NAAQS limits for $PM_{2.5}$ for each city exceed either during a particular period or may be due to pollutants from specific sources, which have to be determined. The cities/locations where $PM_{2.5}$ was > 60% of days above NAAQS limits and cities within the NAAQS limits have to be studied. A detailed account of anthropogenic and other sources of $PM_{2.5}$ exposure have to be assessed for non-attainment and attainment cities. Understanding the emissions, meteorological interventions and chemical characterization of $PM_{2.5}$ are crucial assessment tools for the mitigation of air pollutants (Leigh et al. 2021).

The traditional approach to air quality monitoring is to set up ground monitoring stations and use models that evaluate and predict changes in the air quality at discrete points. Setting up a large number of ground stations for ambient air quality monitoring is not feasible from viewpoint of

resources, expenses, and large manpower requirements. Remote sensing and GIS applications are prominent technologies that use aerosol optical thickness (AOT) as a measure of the extent of pollution in the ambient atmosphere.

Conclusions

There are 132 non-attainment cities in India as per the NACP report published in 2019 after the last updated (2009) NAAQS recommended limits in India. To control the emissions like $PM_{2.5}$ in Indian cities, a relook on the existing NAAQS guidelines is necessary. Graded levels like the interim targets of AQG recommended by WHO air quality guidelines 2021 will be the best approach for India based on the wide concentration difference in the $PM_{2.5}$ in the cities at different geographical locations. A category based on non-attainment/attainment cities and interim targets in NAAQS for each city based on the present $PM_{2.5}$ concentrations may be proposed for a realistic approach to control the air pollution including $PM_{2.5}$ in India.

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Data availability All the data are available in the manuscript.

Declarations

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References

CPCB (2009) National ambient air quality standards India. Central pollution control board. New Delhi, Government of India. Retrieved 25-12-2021, from https://cpcb.nic.in/uploads/National_Ambient_Air_Quality_Standards.pdf

Dandona L, Dandona R, Kumar G, Shukla D, Paul V, Balakrishnan K, Prabhakaran D, Tandon N, Salvi S, Dash A (2017) India state-level disease burden initiative collaborators. Nations within a nation: variations in epidemiological transition across the states of India 1990–2016 in the global burden of disease study. Lancet 390(10111):2437–2460

Ganguly T, Selvaraj KL, Guttikunda SK (2020) National Clean Air Programme (NCAP) for Indian cities: review and outlook of clean air action plans. Atmos Environ X 8:100096

IARC (2013) IARC monographs on the evaluation of carcinogenic risks to humans: Outdoor air pollution, vol 109. International Agency for Research on Cancer, France, p 34

Joss MK, Eeftens M, Gintowt E, Kappeler R, Künzli N (2017) Time to harmonize national ambient air quality standards. Int J Public Health 62(4):453–462

Kesavachandran C, Pangtey B, Bihari V, Fareed M, Pathak M, Srivastava A, Mathur N (2013) Particulate matter concentration in ambient air and its effects on lung functions among residents in the National Capital Region, India. Environ Monit Assess 185(2):1265–1272

Leigh C, Yashar I, Cora J (2021) "Importance of meteorology and chemistry in determining air pollutant levels during COVID-19 lockdown in Indian cities (preprint)"

NCAP (2021) "Urban emissions, 2021. India National Clean Air Programme (NCAP)." Retrieved 25–12–2021, from https://urbanemissions.info/blog-pieces/india-ncap-review/

Sen S, Radhakrishnan V, Nihalini J (2021) Breathing in unhealthy air. Data Point. The Hindu. Print edition 29-09-2021, Thiruvananthapuram edition, p 9

WHO (2021a) "New WHO global air quality guidelines aim to save millions of lives from air pollution." Retrieved 25-12-2021, from https://www.who.int/news/item/22-09-2021a-new-who-global-air-quality-guidelines-aim-to-save-millions-of-lives-from-air-pollution

WHO (2021b). WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide: executive summary. Retrieved 25-12-2021, from https://apps.who.int/iris/handle/10665/345334