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AIR POLLUTION IN INDIA (COMPARING WITH USA AND CHINA)

Chaitanya Malla
TU-Bergakademie Freiberg, Germany
Mail: Chaitanya.Malla@student.tu-freiberg.de

ABSTRACT

India is the second largest country in population with around 1.4 billion people living there stands 5th in economy size and third largest in Purchasing Power Parity (IMF 2018) is unfortunately in top five most polluted Nations list. It falls in Non-Annex group in UNFCCC. Although the country joined in Kyoto and Paris Agreements, the implementations of the measures are at a very slow pace due to various reasons. As the country is not heavily industrialised and with poverty on other hand, people are allowed to use simple alternatives like wood and kerosene-based cooking practises, Diesel powered cars, Thermal power plants (coal based) etc. with weak Government rules against harmful Industries. This causes more Particulate matter (PM2.5, PM10) generation into atmosphere along with many other harmful toxic elements like sulphur dioxide, Nitrous Oxides group and Ozone. Some states are not so strict on environmental regulations resulting in higher overall pollutions in the country. In this paper, a comparison is made for particulate matter between India with China and USA along with few other reported data on health impacts. We observed different trends in between these countries which are discussed further in this paper.

INTRODUCTION

Air pollution is second biggest health issue in India (Dandona 2019). According to Dandona, Air pollution caused 12.5% of total deaths in India, this includes deaths from particulate matter 0.67 million and 0.48 million from house hold pollutions. Many sources reported that India has highest number of polluted cities in the world and stands in the top 5 most polluted countries (World Population Review). 18.1% of global population lives in India and among them air pollution deaths DALYs account for 51.4% of global air pollution deaths (Dandona 2019). These pollutions are mainly caused by vehicles, industries, construction activities, thermal power plants, brick making, biomass and waste burning in the open areas. These are main sources for particulate matter (Lvovsky 1998, Xingchuan et al. 2018, Dandona 2019, Guttikunda 2019, Krishna et al. 2019). According to WHO 2016 report 92% of the world's population is presently exposed to pathetic air quality standards which are above WHO guidelines.

WHO Standards	Annual mean	24hrs mean
PM2.5	10μg/m^3	25μg/m^3
PM10	20 μg/m^3	50μg/m^3

[*DALYs - deaths and disability-adjusted life-years]

Particulate matter assesment can help us to understand pollution levels in the atmosphere and for better planning of preventive measures. Impacts of air pollution are mainly on the public health (Xiong et al. 2017). It has also impact on Global climate change through transportation fluxes.

To reduce the impacts of air pollutions many countries have different preventive measures through amending laws. In USA the acts like Air Pollution Control Act, Motor Vehicle Act and Clean Air Act have major impacts in achieving goals that brought PM recorded data below WHO standards.

Only few western Cities of USA are still just above WHO standards (Schwartz and Hayward 2007).

The countries like China and India have also started their mitigating measures recently by introducing new environmental plans like "Ten Actions" in June 2013 and Air Pollution Prevention Action Plan in September 2013 by China and National Clean Air plan by India (Xingchuan et al. 2018)

Although the Government started preventive measures in India, no positive decline is observed in the particulate matter (Xingchuan et al. 2018). The number of premature deaths in India is around 1.1 million every year with cardio vascular and lung related problems due to air pollution (Xingchuan et al. 2018, Dandona 2019).

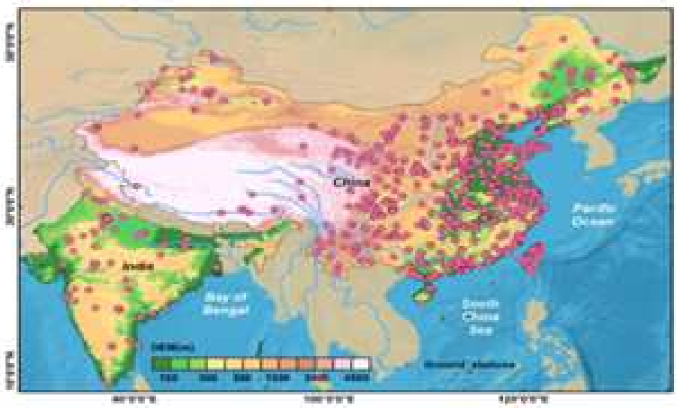
Ground based pollutant measured data were used to compare the situations among the three countries with one German station data included at the end to compare air pollution in these countries. Some other alternative measurements are also made with satellite monitoring data by using aerosol optical depth methods and visibility observations for particulate matter (Wang et al. 2011), but they have uncertainities and cannot reflect the real ground situation (Xingchuan et al. 2018).

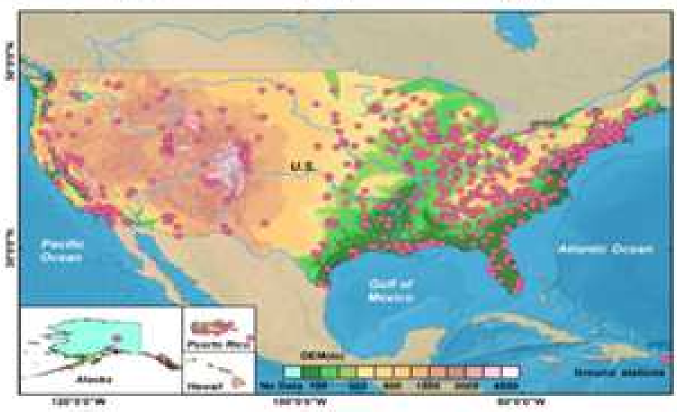
In China, pollutant data were analysed in 31 capital cities and observed strong correlation between PM2.5 and PM10 (Wang et al. 2014). The maximum amount of these particles were also present in the northern region. In India also the particulate matter was high in the northern Indo Gangetic regions (Guttikunda et al. 2014). In USA PM pollution is relatively higher in California and Arizona than other states (Pope et al. 2016)

Information

Name of Country	Number of ground monitoring stations	
China	1568 PM	
India	92 $PM_{2.5}$	573 PM_{10}
USA	838 $PM_{2.5}$	507 PM_{10}

Source: (Xingchuan et al. 2018)





PM data were collected from the ground monitoring stations in India, China and USA.

Before 2015, India was not so good with PM2.5 data and there was not so much data and not many stations according (Xingchuan et al. 2018). The data from 2014 to 2015 were collected from US embassies in India for PM2.5.

Source: (Xingchuan et al. 2018)

For the spatial variations, 11 cities data were projected by Xingchuan et al. 2018 and of 20 cities by Guttikunda et al. 2019).

WHO Particulate Matter Concentrations

Table 1

WHOair quality guidelines and interim targets for particulate matter: annual mean concentrations[a]

	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Basis for the selected level
Interim target-1 (IT-1)	70	35	These levels are associated with about a 15% higher long-term mortality risk relative to the AQG level.
Interim target-2 (IT-2)	50	25	In addition to other health benefits, these levels lower the risk of premature mortality by approximately 6% [2–11%] relative to theIT-1 level.
Interim target-3 (IT-3)	30	15	In addition to other health benefits, these levels reduce the mortality risk by approximately 6% [2-11%] relative to the -IT-2 level.
Air quality guideline (AQG)	20	10	These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to long-term exposure to $PM_{2.5}$

Table 2

WHO air quality guidelines and interim targets for particulate matter: 24-hour concentrations[a]

	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Basis for the selected level
Interim target-1 (IT-1)	150	75	Based on published risk coefficients from multi-centre studies and meta-analyses (about 5% increase of short-term mortality over the AQG value).
Interim target-2 (IT-2)	100	50	Based on published risk coefficients from multi-centre studies and meta-analyses (about 2.5% increase of short-term mortality over the AQG value).
Interim target-3 (IT-3)*	75	37.5	Based on published risk coefficients from multi-centre studies and meta-analyses (about 1.2% increase in short-term mortality over the AQG value).
Air quality guideline (AQG)	50	25	Based on relationship between 24-hour and annual PM levels.

Source: World Health Organisation Air quality Guidelines 2005

These standards are set by World Health Organisation for particulate matter. Interim targets are the achievable set goals for the nations in order to get the air quality better and to reduce the health impacts in their countries. We will discuss the three countries measured data of particulate matter with WHO limits. The recorded ground data were assessed for the years 2014-2017 (Xingchuan et al. 2018).

Comparison between China, India and USA

Table 4.1. Data from Xingchuan et al. 2018

	China				India				USA			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Average PM2.5 concentrations μg/m3												
Mean	45.19	47.60	44.74	41.62	79.70	51.29	88.26	72.13	9.20	8.85	7.92	7.94
Minimum	9.68	11.25	13.99	6.03	19.63	15.16	21.77	25.50	4.48	3.53	4.11	2.79
Maximum	107.95	121.71	122.11	126.02	536.50	242.76	309.56	137.86	20.91	17.57	17.58	21.64
Percentage of days meeting WHO standards after Normalising the Data												
IT-1 (35 $\mu g/m^3$)	30	32	41	46	11	37	11	8	100	100	100	100
IT-2 (25)	8	3	5	15	1	18	1	0	100	100	100	100
IT-3 (15)	3	1	0	2	0	0	0	0	98	98	99	98

Table 4.2. Data from Xingchuan et al. 2018

	China				India				USA			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Average PM10 concentrations μg/m3												
Mean	77.08	81.85	78.75	75.10	103.35	99.83	155.58	136.31	19.54	19.28	18.08	19.03
Minimum	23.42	22.75	29.68	15.07	49.87	56.58	44.66	46.82	9.16	8.23	8.22	7.94
Maximum	159.71	178.34	175.48	211.62	182.82	163.55	646.35	250.15	58.35	57.29	41.35	61.6
Percentage of Days meeting WHO standards												
IT-1 (70)	44	41	46	48	2	4	19	9	100	100	100	100
IT-2 (50)	13	6	9	15	0	0	1	1	99	99	100	99
IT-3 (30)	3	1	0	2	0	0	0	0	96	95	98	94

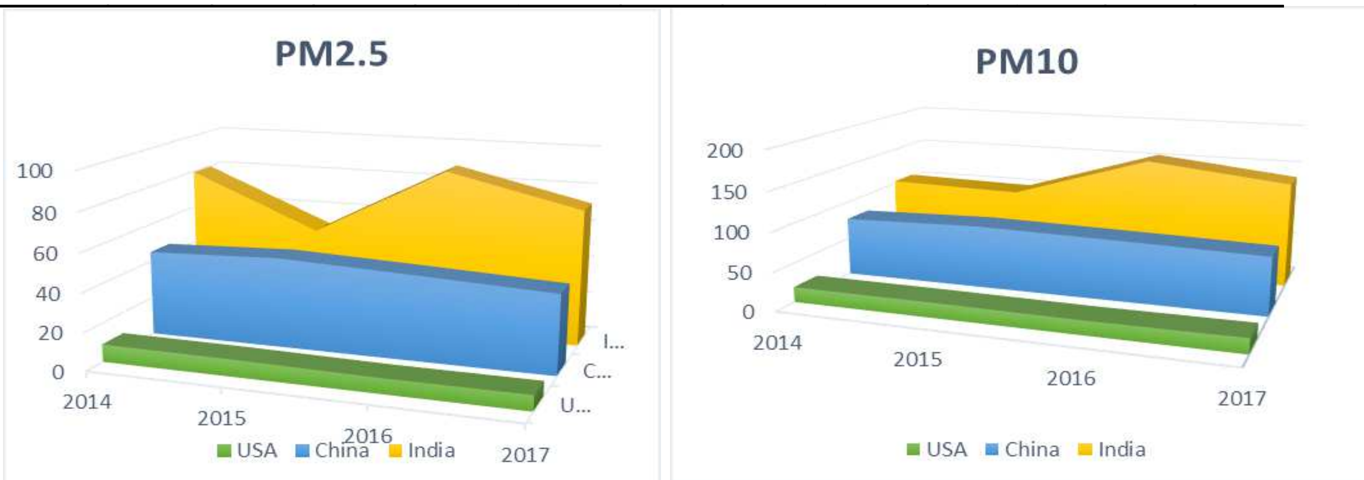


Fig. 4.1. Yearly mean PM

We can clearly see average daily PM2.5 and PM10 concentrations in USA in 2014-17are from 2.79-21.64 µg/m^3 and 7.94-61.06 µg/m^3 respectively, which are far below WHO IT-1 and IT-2 standards. The average daily mean is far below even IT-3 standard for all the years.

The ranges of the daily average concentrations of PM2.5 and PM10 in China are from 6.03–126.03 µg/m^3 and 15.58–217.04 µg/m^3, respectively. PM2.5 increased by 5.33% and PM10 by 6.19% in the years 2014 to 2015. Annual average PM2.5 was 1.28 times and PM10 was 1.12 times of WHO IT-1 standards (Xingchuan et al. 2018) which are a little bit higher. According to Xingchuan et al. (2018), concentrations of both the PMs were reduced after the implementation of air pollution prevention action plan. In China the percentage of days meeting IT-1 standards have increased throughout the years.

The average daily concentrations in India are very much higher than WHO IT-1 standards. PM2.5 ranges from 15.16-536.5 µg/m^3 and PM10 ranges from 44.6-646.3 µg/m^3. The overall PM2.5 concentration is 1.7 times of China and 8.7 times of USA, whereas PM10 concentration is 1.5 times of China and 6.4 times of USA. The concentrations in 2017 decreased by 9.5% for PM2.5 but increased by 31.9% for PM10 compared to 2014. Pollutants trend has hardly been changed.

Satellite data also showed similar range PM2.5 with Aerosol Optical depth measurements. Average Concentration measurements are shown with the spatial map distribution in the figure 4.2.

Fig. 4.2 (A) is annual derived mean surface PM2.5, (B) Pre monsoon, (C) Monsoon, (D) Post Monsoon, (E) Winter. We can clearly see the PM2.5 pollution is higher in the Northern region - Indo Gangetic plain (IGP) compared with Southern region. Winters are more polluted with high emissions in North India than South India because of heating and cooking in North. Industries are also present in these regions, which emit throughout the year and due to thermal inversion in winter more pollution is observed.

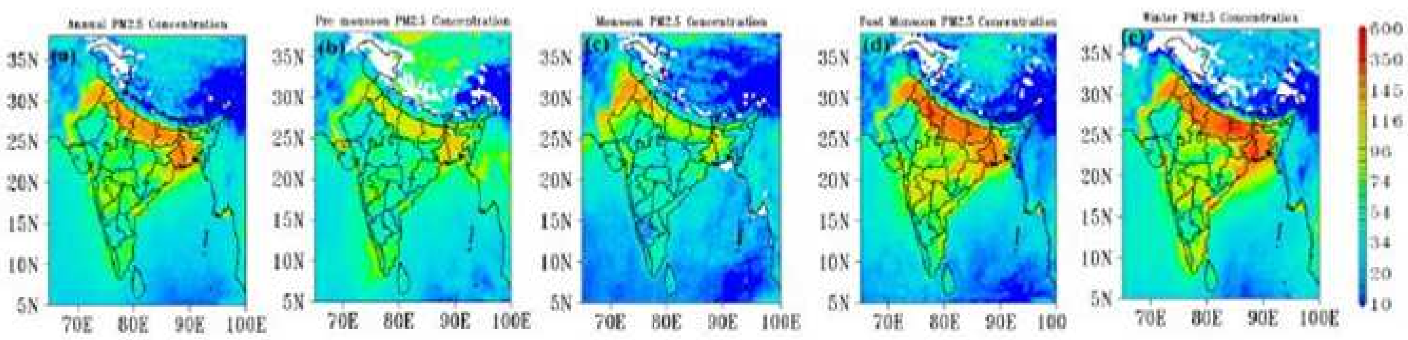
Monsoons are carried by winds from south-India to North-India. Through these winds the long-term PM and other gases transport is also towards Indo Gangetic plain (towards North). On the top of IGP towards further North are Himalayas. These large mountains act as wall for the particles to cross the Indian boundary in North direction. Krishna, et al. (2019) measured PM2.5 concentrations in this region and found annual mean concentration as high as 150-180 µg/m^3.

Even in China similar trends are observed over the country with high PM concentration towards North and Overall high trends in winter (Xingchuan et al. 2018). The most polluted month is December with monthly mean PM$_{2.5}$ 68.19 µg/m^3 and PM$_{10}$ 107.22 µg/m^3. In India PM2.5 is high in January with 142.68 µg/m^3 and PM10 in December with 157.04 µg/m^3. The lowest in both China and India is observed in summer months. India's lowest PM2.5 was in June (30.80 µg/m^3) and PM10 in July (74.53 µg/m^3). Even the lowest PM concentrations measured in the country are above the WHO Yearly mean standards.

In USA the trend is reverse. The western coast has slightly higher concentration with over all high in the country in the summer season. Researchers found that summer wild fires are major source for summer increase in PM concentrations (Xingchuan et al. 2018) and the annual trend of PM concentrations is way below WHO standards with less variation. Air quality in USA was also horrible once upon a time in 1950s but it changed vastly and reached to current positive scenario.

PM concentrations in Germany are also much below WHO standards. PM10 measurements from Melpitz site near Leipzig (major weather station) showed that it has decreased

A B C D E



vastly from year 1993- 2000 and from then there is constant trend 22.4 μg/m^3 with an inter-annual variability of ±2.9 μg/m^3. Although there are influxes to this region from west and east European countries, but the European regulations and industrial emission capping methods reduced the pollutants hugely in their environment (Spindler et al. 2013).

It is clearly found that the PM concentrations are very high in India and made the country stand as one of the top air polluted countries in the world with severe health issues followed by. These high PM concentrations have resulted in cardiovascular and pulmonary related problems among people in the country with 1.24million air pollution related deaths in 2017(Dandona 2019). Of these total air pollution deaths 0.67 million are because of particulate matter pollution related deaths. Out of total deaths by air pollution 51.4 % are premature deaths. No state has PM concentration mean less than WHO guidelines (Dandona 2019, Guttikunda 2019). The share of India in Global DALYs is 26% (Dandona 2019), which is quarter of the whole of world DALYs.

The air pollution related deaths in USA are around 71000 per annum by the year 2010(Yale University 2018), which have been tremendously reduced by half from 1990.

According to BBC (2007) report on Chinese Air pollution, around 350,000-400,000 outdoor air pollution related premature deaths were published. These are less than India's recent year records. Chinese DALYs has reduced compared to 2007.

India has made its own PM levels by Central and State Pollution Control Boards through Environmental Act 1986. These are in between IT-1 and IT-2 standards.

	24 hr Limit (μg/m^3)	Annual limit(μg/m^3)
$PM_{2.5}$	60	40
PM_{10}	100	60

According to Michael Greenstone (2017), the life expectancy in India can be increased by 1 year if it can achieve air quality standards set by itself but by 4.7 years if it achieves the WHO Air quality Guidelines (AQG).

According to OECD 2014 report (Organisation for Economic Co-operation and Development), it is costing India 0.5 trillion dollars per year because of ambient air pollution (Michael Greenstone 2017). The report suggested to invest on clean air to save the air pollution related expenditure and to provide good health to its people.

To conclude, Government should take steps very seriously towards clean air. The Judiciary system should work more efficiently and strongly on Environmental related issues. This needs strong environmental protection Laws in the system. (Michael Greenstone 2017). On the other hand, weather monitoring with advanced equipments is needed with centralized data base in the country (Michael Greenstone 2017). The implementation of catalytic convertors by the government to all the motor vehicles was a great step towards reduction in vehicle emissions. Other scheme like liquid petroleum gas supply to rural areas to reduce wood in kitchen cooking is also a good scheme in reducing indoor pollutions.

Municipal authorities should avoid burning of dump and wastes. This should be seriously taken by Environmental boards. Alternatively, waste recycling and waste management systems should be allowed to take up the recycling task in the country. If possible, government should start its own waste recycling centres. Knowledge should be taken into public about their right for clean Environment by Government as its responsibility, although climate movement has reached from Europe to some Indian cities.

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