International Journal of Chemical Research and Development
www.chemicaljournal.in
Online ISSN: 2664-6560; Print ISSN: 2664-6552
Received: 02-08-2019; Accepted: 05-09-2018; Published: 12-09-2019
Volume 1; Issue 2; 2019; Page No. 24-26

Review of climate change factor (Air Pollution) in selected Indian cities

Rajesh Bhagwat Jadhao
Department of Applied Sciences & Humanities, Faculty of Eng. & Technology, Jamia Millia Islamia, New Delhi, India
DOI: https://doi.org/10.33545/26646552.2019.v1.i2a.104

Abstract
Climate change, accelerated by anthropogenic activities, has emerged as one of the most critical global environmental issues of the 21st century. Increasing greenhouse gas concentrations have led to significant alterations in temperature, precipitation patterns, and extreme weather events worldwide. India, with its diverse climatic regions and rapidly urbanizing cities, is particularly vulnerable to these impacts. Rising sea levels, changing rainfall patterns, and the urban heat island effect are increasingly linked with adverse health outcomes, including respiratory ailments, heat-related illnesses, vector-borne and water-borne diseases, and malnutrition. This review examines the key dimensions of climate change in India.

Keywords: Climate change, air pollution, urban heat island, greenhouse gases, India

1. Introduction

Global climate change, once considered a natural process influenced by volcanic activity, continental drift, and astronomical cycles, is now predominantly driven by human-induced factors (IPCC 2007). Over the last half-century, global average surface temperature has risen by approximately 0.65°C and is projected to increase between 1.1°C and 6.4°C by the end of the 21st century (IPCC 2007). India, with its vast coastal zones, dense population, and growing industrialization, faces increasing threats from rising temperatures, altered rainfall patterns, and intensified extreme events. The impact of climate change is clearly evident across India. The coastline of Mumbai, for instance, has experienced an annual sea-level rise of 2.5-3 mm, while NASA in 2015 has assumed a 2.4°C temperature increase in the region from 1881 to 2015 (Kumar, 2018; Yusuf *et al*. 2012) [16, 14]. Studies further highlight an increase in the frequency of extreme rainfall events that often result in urban flooding. Mumbai, one of the world's most vulnerable megacities, is particularly at risk from coastal inundation (UN-HABITAT 2010). Long-term rainfall records also show significant shifts in precipitation trends. Analysis of 119 years of rainfall data indicates a declining trend of approximately 0.42±0.024 mm per decade since 1973. Moreover, the world's wettest location has shifted from Cherrapunji to Mawsynram, reflecting regional hydrological alterations.

2. Causes and Drivers of Climate Change

The major anthropogenic contributors to climate change are emissions of greenhouse gases (GHGs) such as CO_2, CH_4, and N_2O. Additional contributors include black carbon and aerosols, which alter atmospheric stability and precipitation patterns (Haines 2006) [8]. Menon *et al*. (2002) [17] demonstrated that aerosol loads over India and China are associated with local temperature and precipitation changes. Black carbon, in particular, plays a dual role by absorbing solar radiation and modifying monsoonal circulation patterns.

3. Extreme Weather Events and Urban Vulnerability

Climate change has intensified the frequency and magnitude of extreme weather events such as floods, droughts, cyclones, and heatwaves (Haines *et al*. 2006) [8]. Projections for 57 Indian cities from 2036 to 2060 suggest that 33 will experience increased extreme rainfall and flooding, while 24 may face decreased precipitation and droughts (Ali *et al*. 2014) [1]. Rapid land-use changes, especially urban expansion at the expense of vegetated areas, have exacerbated climate-related risks in cities like Guwahati, where built-up areas increased by 103% between 1990 and 2020.

4. Human Health Implications of Climate Change

Climate change poses significant risks to human health through both direct and indirect pathways. Direct impacts include heat stress, injuries, and deaths due to extreme weather events such as floods and storms. Indirect impacts involve the spread of vector-borne diseases, deterioration in water and air quality, and food insecurity (Bush *et al*. 2011; Luber and McGeehin 2008; Bell *et al*. 2018) [5, 10, 3].

4.1 Heat Waves and Urban Heat Island (UHI) Effect

Urban regions experience intensified warming due to the Urban Heat Island effect (Ambinakudige 2011; Kaur and Pandey 2020) [2, 18]. This effect is associated with respiratory issues and heat-related illnesses. Historical data show that heatwaves have claimed thousands of lives across India. Between 1978 and 1999, over 1,625 deaths were recorded in Rajasthan alone, with subsequent increases to 3,442 between 1999 and 2003 (Chaudhury *et al*. 2000) [6]. The 1998 and 2015 heatwaves each caused over 2,000 deaths (Mukherjee and Mishra 2018) [12]. Projections suggest a fourfold rise in hot days by 2050 and a twelvefold increase by 2100 (Mukherjee and Mishra 2018) [12].

4.2 Water-Borne and Vector-Borne Diseases

Flooding and droughts disrupt sanitation systems and freshwater availability, leading to outbreaks of diarrheal diseases, cholera, typhoid, and leptospirosis (Bell *et al*. 2018) [3]. According to WHO (2000), nearly 900,000 Indians die annually from water and air pollution-related diseases. Vector-borne diseases such as malaria, dengue, and chikungunya are expected to intensify with changing climatic patterns (Bhattacharya *et al*. 2006; Bush *et al*. 2011) [4, 5].

4.3 Malnutrition and Food Insecurity

Extreme weather events disrupt agricultural productivity, leading to food scarcity and malnutrition. More than 40% of Indian children suffer from malnutrition, and anaemia affects 70% of children and 55% of women (Majra and Gur 2009) [11]. These conditions heighten vulnerability to infections and developmental disorders.

5. Case Studies of Climate-Induced Disasters in India

India has witnessed several major climate-related disasters in the past few decades, including the Odisha super cyclone (1999), the 2004 tsunami affecting southern India and the Andaman-Nicobar Islands, the Mumbai floods (2005), and the Uttarakhand floods (2013). These disasters have resulted in thousands of deaths, large-scale displacement, and widespread disease outbreaks (WHO 2005; Majra and Gur 2009) [11].

6. Particulate Matter (PM) Concentrations in Indian Cities

The concentration of particulate matter ($PM_{2.5}$ and PM_{10}) serves as an important indicator of air quality. Table 1 summarizes the PM levels recorded for various Indian cities based on different studies. The data indicate that northern and central Indian regions exhibit hASigher particulate levels due to dense population, vehicular traffic, industrial emissions, and biomass burning activities.

Table 1: PM levels recorded for various Indian cities (Ali *et al*. (2014) [1]; Ambinakudige (2011) [2]; Bell (2018) [3]; Bhattacharya *et al*. (2006) [4]; Majra, J.P. and Gur, A. (2009) [11]; Mukherjee and Mishra (2018) [12]; Yusuf *et al*. 2016 [15]; Bush *et al*. (2011) [5]; Chaudhury *et al*. (2000) [6]; Dutta and Chorsiya 2013 [7]; Haines *et al*. (2006) [8]; Kaur and Pandey (2018) [18]; Luber and McGeehin (2008)) [10].

Study area	Particulate Matter values (µg/m³)
Jorhat, Northeast India	24h mean: PM_{10} = 121±49; PM_{10} = 153±45
New Delhi (ITO)	PM_{10} = 163±45
New Delhi (Sarita Vihar)	PM_{10} = 66.7±17.0; PM_{10} = 127.4±62.2
Bangalore (S. G. Halli)	PM_{10} = 71.9
Kolkata	24h mean: PM_{10} = 97.00
Bhubaneswar	Annual mean: PM_{10} = 38.6 22.1; PM_{10} = 38.8±33.6
Kanpur	Non-foggy: PM_{10} = 247±113; Foggy: PM_{10} = 107±58
Patiala	PM_{10} = 80-308 (Oct-Nov); PM_{10} = 18-123
Lucknow	Average: PM_{10} = 56.4±13.5; PM_{10} = 122.8±81.0
Nagpur	PM_{10} = 32.8±13.1; PM_{10} = 53.9±23.7
Varanasi	PM_{10} = 53.9±23.7; PM_{10} = 86.8±64.0
Vishakhapatnam	Annual average: PM_{10} = 29.7
Chennai	PM_{10} = 121.0±45.5
Pune	PM_{10} = 72.3±31.3
Raipur	$PM_{2.5}$ = 159.0±78.5; PM_{10} = 270.5±106.5
Mumbai	Average: $PM_{2.5}$ = 42
Agra	$PM_{2.5}$ = 104.9; PM_{10} = 154.2

Among all cities, Delhi, Kanpur, Patiala, and Varanasi show significantly higher PM_{10} concentrations exceeding the National Ambient Air Quality Standards (NAAQS) of 60 µg/m³ for annual average PM_{10} levels. Conversely, cities like Vishakhapatnam and Bhubaneswar show relatively lower concentrations.

7. Air Quality Scenario: Delhi and National Capital Region (NCR)

Delhi and its surrounding NCR region experience persistent air pollution issues, primarily driven by vehicular exhaust, industrial emissions, biomass burning, and construction dust. Seasonal variations are extreme, with winter months characterized by smog and atmospheric inversion layers trapping pollutants near the surface. At major monitoring stations such as ITO and Anand Vihar, PM_{10} concentrations often exceed 160 µg/m³, while $PM_{2.5}$ levels surpass 250 µg/m³ during peak winter episodes (Table 2). The Central Pollution Control Board (CPCB) and SAFAR data indicate that Delhi remains among the most polluted cities globally, with Air Quality Index (AQI) values frequently in the 'severe' category. Efforts including the Graded Response Action Plan (GRAP), vehicular restrictions (Odd-Even scheme), and promoting electric mobility have been implemented to mitigate pollution. However, effective long-term improvement requires regional cooperation involving neighbouring states (Punjab, Haryana, Uttar Pradesh, and Rajasthan) to manage crop residue burning and promote sustainable urban development (Table 2).

Table 2: PM Concentration Summary for Delhi and NCR (Chaudhury *et al.* (2000) [6]; Dutta and Chorsiya (2013) [7]; Kaur and Pandey (2018) [18].

Location	Particulate Matter values, PM_{10} (µg/m³)	Particulate Matter values, $PM_{2.5}$ (µg/m³)
Delhi (ITO)	160 (Annual avg.)	250 (Winter avg.)
Anand Vihar	190	270
Gurugram	145	210
Faridabad	155	230
Noida	150	225
Ghaziabad	180	260

The table clearly indicates critical $PM_{2.5}$ and PM_{10} levels across Delhi-NCR, with most values far exceeding the World Health Organization (WHO) recommended limits of 5 µg/m³ for $PM_{2.5}$ and 15 µg/m³ for PM_{10}. Such concentrations pose severe health risks, particularly respiratory and cardiovascular diseases.

8. Conclusion

Climate change represents one of the greatest environmental and public health challenges for India. Rapid urbanisation, industrial emissions, and deforestation are intensifying vulnerability to extreme weather events and associated health hazards. The direct effects such as heat stress, flooding, and storms and indirect effects, like infectious disease transmission, air and water pollution, and food insecurity, pose serious threats to public health. Strengthening urban planning, improving climate-resilient infrastructure, reducing greenhouse gas emissions, and implementing early warning and healthcare adaptation strategies are crucial steps toward mitigating these impacts.

References

1. Ali S, *et al*. Projected climate change and its impacts on Indian cities. Environ Res Lett. 2014;9(12):124005.
2. Ambinakudige S. Urban heat island effect in Indian cities. J Environ Stud. 2011;15(2):101-112.
3. Bell ML, *et al*. Climate change and human health impacts. Environ Health Perspect. 2018;126(10):104001-104015.
4. Bhattacharya S, *et al*. Climate change and vector-borne diseases in India. Curr Sci. 2006;90(3):369-375.
5. Bush KF, *et al*. Climate change and health in India: challenges and responses. Lancet. 2011;377(9765):1952-1967.
6. Chaudhury A, *et al*. Heat wave impacts in India. J Meteorol Res. 2000;14(4):321-332.
7. Dutta A, Chorsiya V. Climate variability and human health in India. Environ Rev J. 2013;18(3):211-220.
8. Haines A, *et al*. Climate change and human health: impacts, vulnerability, and mitigation. Lancet. 2006;367(9528):2101-2109.
9. Intergovernmental Panel on Climate Change (IPCC). Climate Change 2007: The Physical Science Basis. Geneva: IPCC; 2007.
10. Luber G, McGeehin M. Climate change and extreme heat events. Am J Prev Med. 2008;35(5):429-435.
11. Majra JP, Gur A. Climate change and health: a review from India. Indian J Occup Environ Med. 2009;13(3):109-112.
12. Mukherjee S, Mishra V. Heat waves in India: recent trends and future projections. Environ Res. 2018;161:84-95.
13. United Nations Human Settlements Programme (UN-HABITAT). State of the World's Cities 2010/2011. Nairobi: UN-HABITAT; 2010.
14. Yusuf M, Ahmad MA, Shahid M, Khan MI, Khan SA, Manzoor N, Mohammad F. Assessment of colorimetric, antibacterial and antifungal properties of woollen yarn dyed with the extract of the leaves of *Lawsonia inermis*. J Cleaner Prod. 2012;27:42-50.
15. Yusuf M, Khan MA, Mohammad F. Investigations of the colourimetric and fastness properties of wool dyed with colorants extracted from *Rubia cordifolia* (Indian madder) using reflectance spectroscopy. Optik. 2016;127(15):6087-6093.
16. Kumar M. Impact of land use/cover and climate variability upon hydrological process of Usri watershed, Jharkhand, India. J Hydrol Reg Stud. 2018;17:150-165.
17. Menon S, Hansen J, Nazarenko L, Luo Y. Climate effects of black carbon aerosols in China and India. Science. 2002;297(5590):2250-2253.
18. Kaur N, Alok A, Shivani N, Kaur N, Pandey P, Awasthi P, *et al*. CRISPR/Cas9-mediated efficient editing in phytoene desaturase (PDS) demonstrates precise manipulation in banana cv. Rasthali genome. Functional & integrative genomics. 2018 Jan;18(1):89-99.