Current scenario of air pollution in relation to respiratory health

We inhale 420 litres of oxygen and exhale 350 litres of carbon dioxide per day. This gas exchange happens in the air sacs called alveoli which are over 600 millions and lined by thin membrane of 0.3 micron. These alveoli are connected by over 100–200 million patient branching bronchial to accommodate 10,000 litres of air and 10,000 litres of blood should circulate per day to carry oxygen to all the cells in our body. We need to breathe clean air to maintain our health.

The analysis of skulls belonging to various ages by CT scan in relation to air pollution in the UK has shown that the incidence of chronic sinusitis during the Bronze Age and Iron Age was 0.5% when there was no cooking; in the Romano British Age it went up to 3%, when food was cooked outside; in the Anglosaxon Age it went up to 7% when civilized population started cooking food inside their huts. It was in the medieval period that the smoke chimneys came into existence, and sinusitis dropped down to 3.5% (ref. 1). Further, the 13th and 17th century environment crises were due to growth in urban population, increased density of population and change in use of fuel from wood to coal. In 1773 John Arbuthnot[2] reported on poor air quality in lungs leading to high death rates in urban infants from sulphurous steams of fuel.

Visvesvaraya[3] while addressing the Bengaluru Literary Union on 20 May 1953, mentioned that the city has grown by 90% in one decade, becoming overcrowded with slums increasing; the lung space is being utilized for construction and we need a self-examination on the moral health of our country.

Air pollution not only triggers existent asthma, but also changes the genetic pattern[4].

Prenatal exposure of suspended particulate matter (SPM) of 2.5 micron, when the concentration in the air is increased from 35.5 to 53.4 micron there will be four-fold increase in wheezing episodes in children[5]. Table 1 lists the main sources of air pollution[6–8].

Air pollution, climate change and global warming are interrelated. Carbon dioxide in the environment enhances the greenhouse effect and thus contributes to global warming. During the Industrial Revolution in the mid-1800s, burning of large quantities of fossil fuels was a prominent feature. In addition, rapid deforestation, automobile emission, burning of coal, urbanization and intense animal agriculture to meet the needs of non-vegetarians are the man-made causes for air pollution[9].

Global warming and climate change worsen the pollen allergies globally by prolonging the flowering season, growth of new weeds like ambrosia in Scandinavian countries and by producing more potent pollens. SPM2.5 from diesel particle-coated pollen is 50 times more allergic and produces stronger symptoms.

According to a report on ambient air pollution, PM 2.5 μm, ozone and tobacco smoke are the major contributors to mortality risk factor[10].

Air pollution has an impact from womb to tomb: Foetal development is moulded by the maternal environment. The biological programming is an accepted reality and contributes to the development of the respiratory system along with other systems. Living close to busy roads is associated with high risk of sensitization to pollen[11]. Holloway *et al.*[12] found dust mite antigens in amniotic fluids at 16–17 weeks of gestation and in cord blood at 37 weeks of gestation. The current understanding is that the paternal environment is also important for the offspring, especially during the critical windows of development.

Air pollution is the major cause for increase in prevalence of allergic airway diseases like asthma. It is a global health epidemic affecting over 1 billion people at present; it is anticipated that 4 billion will be affected by 2050. It also causes 8 million deaths per year. Air pollution, global warming and climate change will be the defining issues for the health system in the 21st century[13].

A report from the National Commission of Macroeconomics and Health, Government of India shows that chronic obstructive pulmonary disease (COPD) and asthma are the major non-communicable diseases affecting more people than cancer, ischaemic heart disease, stroke and diabetes put together[14].

Our observations in Bengaluru showed that the incidence of asthma in children increased from 9% in 1979 to 25.5% in 2009. There was slight decrease in incidence of the disease by 4% between 1999 and 2009, as observed in other countries like the UK, Hong Kong, Mexico and Australia due to saturation of genetically predisposed population. Nevertheless, persistent asthma has increased from 20% to 72.5% and persistent severe asthma has increased from 4% to 11% between 1994 and 2009 (Figure 1)[4–7,14–16].

We correlate that increased prevalence of asthma is due to rapid urbanization, change in demography, increase in the number of automobiles and air pollution.

Electron microscopy of nasal mucosal biopsy from children in polluted cities showed that all parameters are abnormal compared to clean cities. The important parameters are excess mucus production and stagnation from ciliary damage and inactivity leading to infection and other complications[17].

The study by Kulkarni on healthy 64 children in Leicester UK, in the age group of 8–15 yrs and checking the carbon particles in the alveolar macrophages on an

Table 1. Main sources of air pollution[6–8]

	Indoor air pollution	
Outdoor air pollution	Aero-biological	Irritants
Automobile exhaust	Dustmite – 60.00%	Tobacco smoke
Power plant emission	Cockroach – 25.00%	Mosquito coil burning
Open burning of solid waste	Fungi – 07.50%	Cooking fuel
Construction-related activities – dust	Pollen – 07.50%	Formaldehyde volatile compounds from furniture made from compressed wood, panel boards, etc.
Mining activities	Pets – 05.00%	
Pollen and fungi		

Table 2. Impact of air pollution on health[10,25]

Respiratory	
Upper respiratory tract	Allergic rhinitis; sinusitis; middle ear infection, inflammation; blockage of tear duct; enlarged adenoids; chronic cough
	Sleep disordered breathing
	Obstructive sleep apnea syndrome
Lower respiratory tract	Chronic cough
	Bronchitis; asthma; pneumonia
	Emphysema; chronic obstructive pulmonary disease
Cardiovascular	High blood pressure
	Increased coagulation of blood
	Heart attack
	Stroke
Increase in oxidative stress on all organs	Insulin resistant (diabetes mellitus)
	Promotes endothelial damage
	Decreased cognitive function
	Attention deficit and hyperactivity
	Autisum in children
	Dementia in adults
	Sudden infant death syndrome (not established)
	Cancer

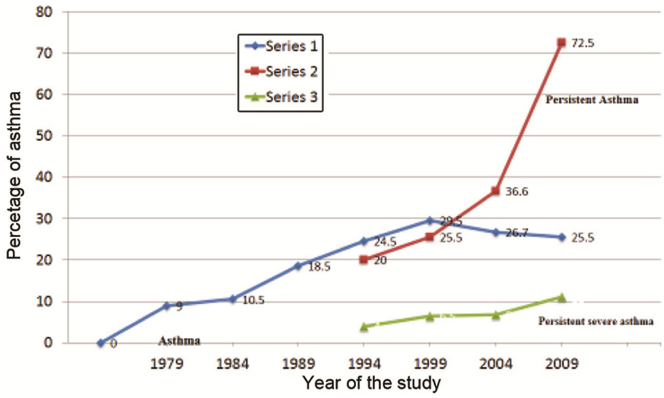

Figure 1. Trends of asthma prevalence in Bengaluru.

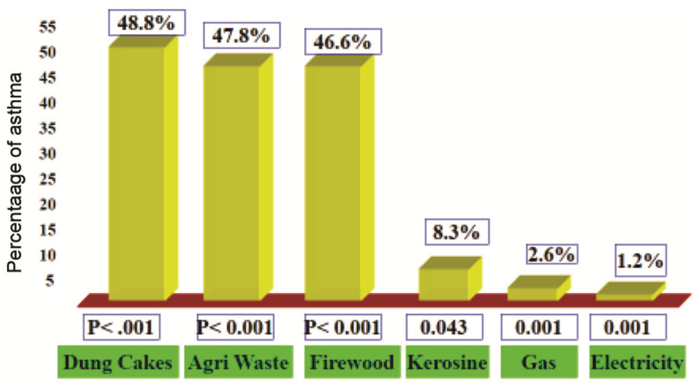

Figure 2. Cooking fuel versus prevalence of asthma in children.

induced sputum (ref. 2), there is 17% decrease in forced expiratory volume per second and 34.7% decrease in small airway airflow (FEF-25–75%)[18].

Inhalation of radio isotope ^{99}TC (2.5 μm particle size) showed its presence in the blood within 1 min and peaked after 10–20 min in all the tissues of the body[19].

The reactive oxygen species from oxidative stress affects the airways by smooth muscle constriction, increased vascular permeability, impairment of beta adrenergic receptors, excess mucus production, altered release of inflammatory mediators, airway hyperactivity, epithelial damage and ciliary inactivity.

Allergic rhinitis (AR) in the general pediatric population increased from 22.5% to 27.5% between 1994 and 1999, and in asthmatic patients the incidence of AR also increased from 75% to 99.6% between 1999 and 2011 (refs 20, 21).

The prevalence of chronic cough for over two weeks duration increased from 8% to 21.25% between 1999 and 2017. The other clinical features associated with chronic cough that have shown an increase are: snoring, 42.45%; mouth breathing, 43.4%; conjunctivitis (rubbing of eyes), 27.35%; bruxism, 18% and sleep disordered breathing (SDB), 26%. However we have observed that in pediatric patients, generally SDB is 8% and obstructive sleep apnea syndrome is 1.05%. The most common causes for SDB in children are allergic rhinitis, asthma and adenoidal hypertrophy[21,22].

It has also been observed that chronic sleep disorder increases insulin resistance and diabetes, increases heart rate and blood pressure following sleep-deprived rights. Women who have less than 5 h of sleep have a 30% increased risk of developing coronary heart disease[23].

Further observations on outdoor air pollution indicate the following[5–7,20,21].

- Children in heavy traffic school areas suffer more from asthma and it increases further in children from lower socio-economic background.
- Urban children suffer more than rural children.
- In urban children, the prevalence of asthma in summer increased from 2% to 28.5% in 15 years and was hypothesized due to ozone production from slow traffic and higher emission in bright sunlight.
- Double the number of traffic police personnel suffer from asthma, chronic cough and other symptoms than non-traffic police personnel.
- Asthma visits to the emergency rooms in hospitals increased to 100% during 3 days of Diwali festival from increased sulphur-dioxide in the air due to bursting of fire crackers.
- Lead poisoning study children in Bengaluru was 4.6 micron when we were using leaded petrol content of 0.59 G/litre.

Table 3. Measures to mitigate air pollution[10,25]

Outdoor	Indoor
Short-term interventions	
Identify the source of pollution	Quality education
Adopt dust management procedures	Encourage commercial cooking fuel
Mandate fuel quality	Build houses so that there is good sunshine and cross-ventilation
Engine standards	Avoid tobacco smoke
Free flow of traffic	Avoid wall-to-wall carpets
One way	Use indoor plants and expose them to sunlight and remove water from the tray once a week
Bus day	
Vehicle-free day	
Medium-term interventions	
Upgrade public transport	Use clean fuel
Control diesel vehicles	Cleaner cook stoves
Use of electric vehicles	Upgrade heating and other solid fuel systems
Increase greeneries, maintain parks, playgrounds	Avoid tobacco smoke
	Minimize cockroaches
	Maintain houses
Long-term interventions	
Expand/upgrade public transport	Eliminate solid fuel for cooking and heating
Use walkways, cycle paths, etc.	Full access to clean fuel
Maintain footpaths	Solar energy
Discourage the use of personal vehicles	Atomic energy
Establish satellite cities	
Good waste management	
Clean drains and chimneys	
Research on our traditional values in prevention of airway allergies from air pollution	
Carbon sequestration measures	
Legal activism	

Observations regarding indoor air pollution[6,7,15,16]:

- Data show that in India there are 1.15 million premature deaths per year; 85% of them are women and children. Chulhas using solid cooking fuel release smoke equivalent to 400 cigarettes per hour.
- Ill-ventilated huts where biofuel is used for cooking has resulted in more girls suffering from asthma compared to boys, contrary to other studies.
- Asthma in well-ventilated houses is 8% and in ill-ventilated houses is 42.7%.
- Use of non-commercial cooking fuel like dung cakes, agri waste and firewood increased the prevalence of asthma by 48.8%, 47.8% and 46.6% respectively. On the contrary, use of commercial cooking fuel like kerosene, gas and electricity showed prevalence of asthma at 8.3%, 2.6% and 1.2% respectively (Figure 2).
- Single-parent smoking in the house resulted in prevalence of asthma at 22.8%; in the case of non-smoker, it was 8%.
- Single-room dwelling with agri waste as cooking fuel showed 10.5-fold increase in the incidence of pneumonia.

Data from the global carbon project 2017 show that the global CO_2 emission has steadily increased from 1960 to the current level of 36.8 billion metric tonnes, and it is the major source of air pollution and global warming; other sources add only 4.8% (ref. 24).

Lakeside Education Trust and the George foundation of USA did research work on lead poisoning followed by an international conference in Bengaluru on lead poisoning which influenced to ban the lead in the petrol in 1999.

Further to that our study from 1979 to 99 on rapid urbanization and change in the demography which increased the prevalence of respiratory allergy was utilized by Bhurelal committee to clean up mega cities and maintain school environment in 2004 study on traffic and non-traffic police officers where double the number of traffic police suffer from air pollution was discussed in the parliament and recommended face mask in 1999. The banning of tobacco smoke in public places started at century club a social club founded by Visvesvaraya in 1995, in Karnataka in 2001 and in India on 2003.

Social education on ill effect of smoke from bursting of crackers brought supreme court order in restricting the use of fire cracker and training in the year 2017 and 2018.

Air pollution causes obstructive lung diseases with spinal problem. In school children carrying heavy back pack would worsens the spinal health, neck problem these children suffer more with morbidity and mortality during their adulthood. This observation resulted in limiting the weight of back pack to 10% of the body weight by supreme court of India in 2018.

We can have clean air and decrease in global warming by 2030 with sincere efforts of all stakeholders.

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Genesis of the Dhuadhar Falls, Bhedaghat, Madhya Pradesh, India

Dhuadhar Falls in Bhedaghat near Jabalpur, one of the most sought after tourist destinations in Madhya Pradesh, India, attracts thousands of tourists throughout the year. The mighty River Narmada drops (Figure 1 *a*) 30 m down into a deep gorge of marble rocks, creating one of the most beautiful natural sites. Although there is a lot of literature available describing the surrounding rocks like marbles and schists of Precambrian Mahakoshal group, Lamheta Formation of the Cretaceous and the Deccan Traps[1–3], there is hardly any work explaining the genesis of the Falls itself. The River Narmada flows almost in a straight line along the Narmada–Son Lineament (NSL) marking the boundaries of some of the important basins of India[4]. No Gondwana rocks (between late Paleozoic to Mesozoic age) are found to the North of the NSL and no Vindhyan supergroup rocks (~1700–800 Ma) are found to the south of the NSL[5]. This suggests that the feature has acted as a depositional basin boundary since Precambrian and continued until the deposition of Gondwana. The Deccan Traps rest directly over the Vindhyan supergroup in the north without any Gondwana rocks in between, which records a long hiatus in geological time. The Gondwana lies over the Archean basement and no Vindhyan supergroup is found to the south of the NSL. Hence, this too documents a long time gap in the geological record but at a different time interval. The NSL can be best defined as a narrow Archean/Bijawar strip which is faulted (EW strike), and it marks the boundary of the Vindhyans to the south and Gondwana to its north[6,7].

Here we document a few geomorphological observations which could throw some light on the possible mechanism by which the Dhuadhar Falls came into existence. One of the most common explanations amongst geologists is the presence of ‘cross faults’[5] across River Narmada, related to the NSL, creating ‘step’-like flow path of the river ornamented with several falls. This could be true for many other falls like the Ghughra Falls (Figure 1 *b*; situated 3 km upstream from Bhedaghat near Lamheta Ghat), but Dhuadhar certainly compels us to come up with an alternate explanation.

Figure 1 *c* shows the channel morphology of River Narmada in and around Bhedaghat. Channel A represents the current flow path, whereas Channel B shows the abandoned palaeo flow path of the river. It can be postulated from Figure 1 *c* that the Narmada once flowed through Channel B, but has changed its course and now flows through Channel A. We wanted to examine why such a change would have occurred and it left us with a possible explanation for the genesis of the Falls. We would now like to draw the reader’s attention to the lineaments mapped (red lines, Figure 2 *a*) on the marble rocks in that area. These linear features are nothing but deep gorges formed by the weathering and