SAVITARKA

An E-Magazine on Sustainable Development Issues

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Editorial

Savitarka *is a magazine to widely disseminate the outcome of research and action on sustainable development issues. It discusses technological, socio-economic and policy aspects of various development sectors including energy, environment, infrastructure, human development, agriculture, rural development, urbanization, water resources, irrigation, etc., in a comprehensible form. For increased visibility, articles published in this magazine can be written in any language.*

In general, people are not aware of the complex research articles written in scientific and technical journals. **Savitarka** *intends to generate mass awareness by sensitizing people with simple illustrations of complex research. It is a platform for identifying the issues; logical discussions on them and suggesting some possible remedial solutions through appropriate interventions.*

Savitarka *envisions to enlighten people to adopt an ecofreindly way of life and contribute to sutainable development.*

This Speccial Issue of **"Savitarka"** *is dedicated to Professor Rashmi S. Patil, of IIT Bombay, who ssuccummed to COVID-19 on September 01, 2020.*

With Deepest Gratitude and Warmest Affection,
We dedicate this issue of SAVITRAKA to

Prof. Rashmi S. Patil

(March 26, 1946 - September 01, 2020)

- Editorial Board Members of SAVITARKA

Contents

Biography of Prof. Rashmi S. Patil, my Ajji, from my heart

Adi, Grandson of Prof. Patil

Is it possible to influence people around you without being very famous? Yes it is. My grandma was like that. She helped so many people, both professionally and on personal front. She was amazing. I loved my grandma. We had so much in common. We loved the same foods. We loved the same chocolates. Samosas were her favorite snack. They are mine too. She loved mint chocolate. Same here.

She was born in Kanpur, India on March 26, 1946. Her father was a famous chemist and her mother was a school principal and a writer. She lived in Kanpur, then Allahabad, and then Jaipur for college and then she moved to Delhi. Grown up, She got her PhD in Delhi University when she was 26. She got a PhD in physics, where she met my grandpa. She got married to Prof. Sharad Patil, my grandpa in 1971! She had her first son Siddharth Patil (my dad) when she was 27 and had Bharat Patil when she was 30. She has a brother and sister. The brother's name is Piyush Mehrotra who is 65 and sister's is Shalini Mehrotra who is 60.

She became a professor in first Physics, and then Environmental Science in IITB, Mumbai, and, she won many awards including the best teacher award. She worked on building things in people's everyday life to reduce pollution! She did this so kids like me can grow up in a cleaner planet! She retired when I was three years old at the age of 68! After she retired, she came to visit me and we had lots of fun. We used to play lots of Scrabble but when she went back to India we got an app called Words. Words is like Scrabble online.

She recently passed away on September 01, 2020 and it was a tragic time for us all. She passed away in the presence of her son, Siddharth, my dad. She left because of the darn coronavirus. We got together on Zoom and shared memories and happy moments with the family. We have decided that she would not want us to be sad, but happy! We are very proud of her to this day, for she was an amazing person. I will always remember her with love.

Prof. Rashmi S. Patil: A Memoir

Associates and Students of Prof. R.S. Patil

Dr. Prasad Modak, Former Professor ESED (formely, CESE), IIT Bombay

It was 1973 and I was an undergraduate student at IIT, Bombay. Prof Patil was then a demonstrator in the Physics Laboratory. She was very young, must be around 30 in age. In the final exams, students were allotted experiments to perform and I was given the experiment to find the value of G – acceleration due to gravity.

I was so delighted to get this experiment as the answer was already known as 9.8 m/s2 . I had to just swing the pendulum, record the time and find G using a formula. So, I happily stepped out to the balcony and was watching the passers by. There was no hurry. Prof Patil came to me and smiled (she always had an infectious smile). She softly said "Sometimes you already know the truth, but you have to experience it to understand how you cannot still reach to it. Your pendulum experiment is not going to give you the precise value of 9.8, despite your best efforts. So give a try and learn why."She was absolutely right. Teachers have a subtle way to say so many things that are unspoken.My salute to Professor Rashmi Patil. I remember days at CESE IIT Bombay where I was a lecturer in 1984. Prof Patil expired in Mumbai on September 1. Her sudden death was a shock to all of us. Professor Patil taught at the Centre for Environmental Science and Engineering (CESE) at IIT Bombay.

- **Prasad Modak** (https://prasadmodakblog.com/2020/09/05/revisiting-the-joy-of-teaching/)

Dr. Vinod K. Sharma, First Ph.D. Student of Prof. Rashmi S. Patil, and, Professor at IGDIR, Mumbai, India

Prof. Rashmi S. Patil, my revered mentor and guide, has left a deep impact on my life. During 1986-87, when I decided to pursue my Ph.D., I contacted several professors within India and abroad. My search for a perfect guide ended after meeting Professor Rashmi S. Patil of CESE, IIT Bombay in 1987. Being a faculty member at University of Jodhpur then, I had only 3 years' leave to complete my Ph.D. Initially, she was skeptical about me being able to complete my research in such a short time. However, after my much persuasion she agreed to guide me. I must mention here that professional excellence and personal humility of Prof. Patil encouraged me to overcome all hardships that I encountered during my Ph.D. research. Due to her constant motivation and tireless efforts, I was not only able to complete my Ph.D. thesis on relatively new topic i.e. air pollution within three years but outcome of my theis was published in 14 papers in refereed journals, conferences proceedings and a book. Thus, her encouragement in academcis also brought to me four job offers within India and abroad. I will always remain grateful to Prof. Rashmi S. Patil, who inculcated in me a culture of honest professionalism and simplicity, a path to personal happiness.

- **Vinod** (profvksharma.in@gmail.com)

Dr. Sunita Purushottam, Head of Sustainabilit y, Mahindra Lifespace Developers Ltd, Mumbai.

Winter of 1997, I was in IIT Delhi for a conference to present a paper on mixing height and there I saw Madam for the first time and learned that she is from IIT Bombay. Her work too was on mixing height and air pollution and so was mine. She appeared kind and approachable. I don't recollect if I spoke with her, but I had felt my heart racing - thinking, one day I will work with her. Back at NEERI, I applied for a CSIR fellowship and was awarded the same. I had forgotten my resolution (I got married) and my husband moved to Bombay. I was still in Nagpur - till one good friend suggested that I apply to IIT Bombay. I did and also learned that I could transfer my fellowship to IIT Bombay. I appeared for the interview (with a PhD topic in hand ! and the Guide in mind - Prof Patil! I was pushing my luck too hard - who appears for a PhD interview with topic and guide in mind? But my guidelessness had led to a serious vacuum in my mind - each day spent on thinking on how can I finish a Ph.D. without a guide!). It was my good fortune to have madam as my guide. I am so proud to be her student. Today she is no more - but the last message from her - "Blessings to you and your family" pushes me on. In all my conversations with her, she would ask about my son, and her abundant blessings were showered on us. She was so proud of her students and went out of her way to help and influence so many of us. She was the perfect guide for me a strong women mentor and a person with no pretense and a lovely human being. In front of her, you could just be yourself! Her eyes sparkled and her smile melted all your worries! Prof R.S. Patil was a globally renowned air pollution scientist, but for me, she was my perfect guide. I pay my tribute to my guide on Teacher's Day! She came into my life magically and today there is a vacuum, but I feel her abundant blessings and pray for her soul. Professor Patil was a gem of a person. She was very kind and yet firm with her students. Her style of teaching was lucid and clear. Love and discipline went hand in hand. She was invested in each student and guided each of them with a firm yet caring manner. Behind effervescent smile was a sharp mind. A rare teacher whose teaching extended beyond classroom. It was my good fortune to be able to work with her. I am indebted to Patil mam for her patient guidance."

- Sunita (sunita.purushottam@gmail.com)

(https://www.linkedin.com/pulse/search-perfect-guide-dr-sunita-purushottam)

Mr. Vinayak Padalkar, Indian Railways

Prof. R. S. Patil was not only my M. Tech guide but also a motherly figure for me. She helped me sail through academics by understanding my commitments and also supported me in my personal issues. Alongwith my progress in academics, she also helped me in growing professionally. On several occasions, she went an extra mile for my project and studies. I always admire her for her compassion towards students and her commitment towards her profession. I will always remember her as a person who supported during my tough times. Lord Ganesha may give peace to her soul."

Vinayak (vinayak.padalkar@gmail.com)

Dr. A. Vinod Kumar, Head, Environmental Monitoring & Assessment Division, Bhabha Atomic Research Centre, Trombay, Mumbai 400085

I am indebted to Madam for all the encouragement and guidance during my PhD and during my career at BARC. The affection and care showered on students is unforgettable. We all students will miss her. May her soul rest in peace."

- **A. Vinod Kumar** (avinodkumar2015@gmail.com)

Dr. Sujata Bhaker, Director, Sun-photonics Limited

I would like to express my deep condolences to all the loved ones of Respected Prof. R.S. Patil. Half or One page would not be sufficient to express my thought or feeling for Prof. R.S.Patil. I still remembered my interview day in IIT Bombay, she supported and helped me to get through the admission process. I have not done any project and research work under her, but I was in the AIR group (worked under Prof. V.Sethi). She was so charming, calm, and caring person. She was one of the rare teachers who taught me not only her course but also important lessons of the life. I was so lucky that I was connected with her and my association with her will always be memorable.

May her Soul Rest in Peace.

- **Sujata Bhaker (Email**: sujata@sun-photonics.com; sujatabhaker@gmail.com)
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Linkdein: https://www.linkedin.com/in/sujata-bhaker-202a72a4

Dr. Milind Kulkarni, Director, Prachi Services Inc

I did PhD under madam during 1994-98. At that time, I was working as Professor in Mumbai and while teaching the subject of Air Pollution, I was always feeling that policy makers and curriculum give more importance to Ambient Air Quality and data on Personal Exposure to Air Pollution which is more important from health risk point of view is rare in India. With this point in mind, I approached Professors at CESE, IIT Bombay and I found area of madam was very close to what was in my mind. Moreover she was working on a project sponsored by Central Pollution Control Board on similar topic. I thoroughly enjoyed working under her. She accompanied me in Marol MIDC area of Mumbai during the selection of respondents. We also did health assessment study in collaboration with KEM Hospital and one camp was organised in CESE itself. She encouraged me to publish papers in national and international conferences and journals and I could do my first foreign visit to Seattle, USA to present my paper in 1996 while doing PhD. She fondly used to call me a star student. We were in touch even after PhD days. She was very humble and caring. When she came to know that I was suffering from jaundice, she called me and told what care should be taken so that I will recover fast. She taught us the course of Environmental Systems & Modelling where we came to know about the amazing depth of her knowledge. She left us early and left a void in our lives which is difficult to fill.

- **Dr. Milind Kulkarni (Email:** milkulkarni@gmail.com)
Linkedin: www.linkedin.com/in/milind-kulkarni-a885bb64))

Dr. Sangeeta Sharma, Executive Director, National Ecology and Environment Foundation (NEEF)

We are happy to coordinate and host Professor R.S. Patil memorial Webinar. I met Prof. Patil when we invited her as the Keynote Speaker for our international conference. Prof. Patil was on the Panel of Experts of NEEF in the area of Atmoshperic Pollution and also examined a couple of theses of our PG students. We will miss her contributions to our education programs, research and academic events. She was not only professionally meticulous but also an affable and warm hearted person. I sincerely express my gratitude to Prof. Patil for her association with NEEF.

- **Sangeeta on behalf of the Staff and Trustees of NEEF**
- **(Email**: ed@neef.in; admin@neef.in)

Mainstreaming Ventilation Coefficient in Management of Air Quality Containment Zones

Sunita Purushottam *

Abstract

Understanding micro-meteorology is the key for management of urban air pollution. Mixing of pollutants in the atmosphere is a function of temperature, pressure and wind. Understanding the ability of the atmosphere to disperse pollutants can guide regulators and authorities to come up with a suitable action plan for improving air quality. Mixing height is the height upto which pollutants can convectively mix. A product of mixing height and wind speed is known as ventilation coefficient (VC), which varies temporally and spatially. Value of VC lower than 6000 m2/s is a precursor of air pollution episode. Urban local bodies can, therefore, effectively avoid air pollution episodes by laying out strict warnings based on local meteorological conditions. This article explores the possibility of mainstreaming ventilation coefficient in management of air quality containment zones.

Introduction

Air Pollution is one the most challenging problems of our times. Though it is known to all that air pollution is a serious health issue, and out of 30 most polluted cities in the world, 21 are in India. With rapid urbanisation our need for energy for homes, production of goods and services, transportation of people and goods is rising rapidly[1]. Increased affluence leading to rapid consumption of energy, goods and services coupled with inefficient waste management, plus age hold practices of crop residue and roadside dust – create a very unhealthy cauldron for urban residents. It is interesting to note however that in India awareness on air pollution and its health impacts is heightened during the winter months. A snapshot of google searches on air pollution is given as follows.

[1]https://ourworldindata.org/grapher/per-capitaenergyuse?tab=chart&time=earliest..2019&country=~IND&region=World

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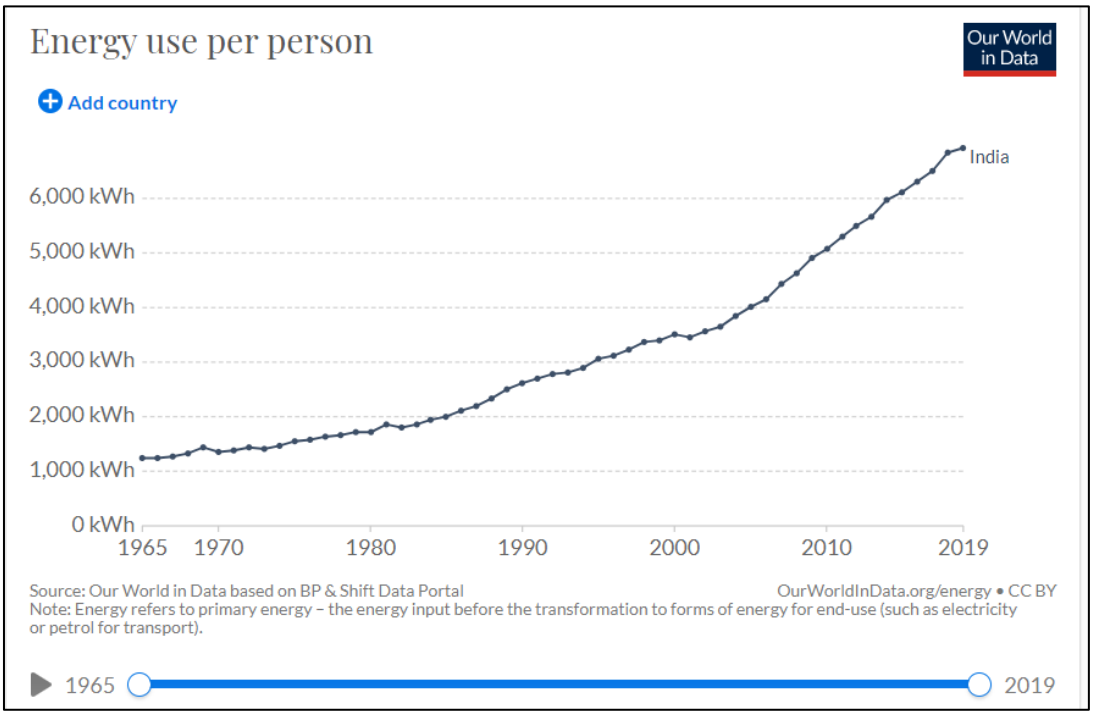
Energy use per person
Our World in Data
Add country
India
6,000 kWh
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4,000 kWh
3,000 kWh
2,000 kWh
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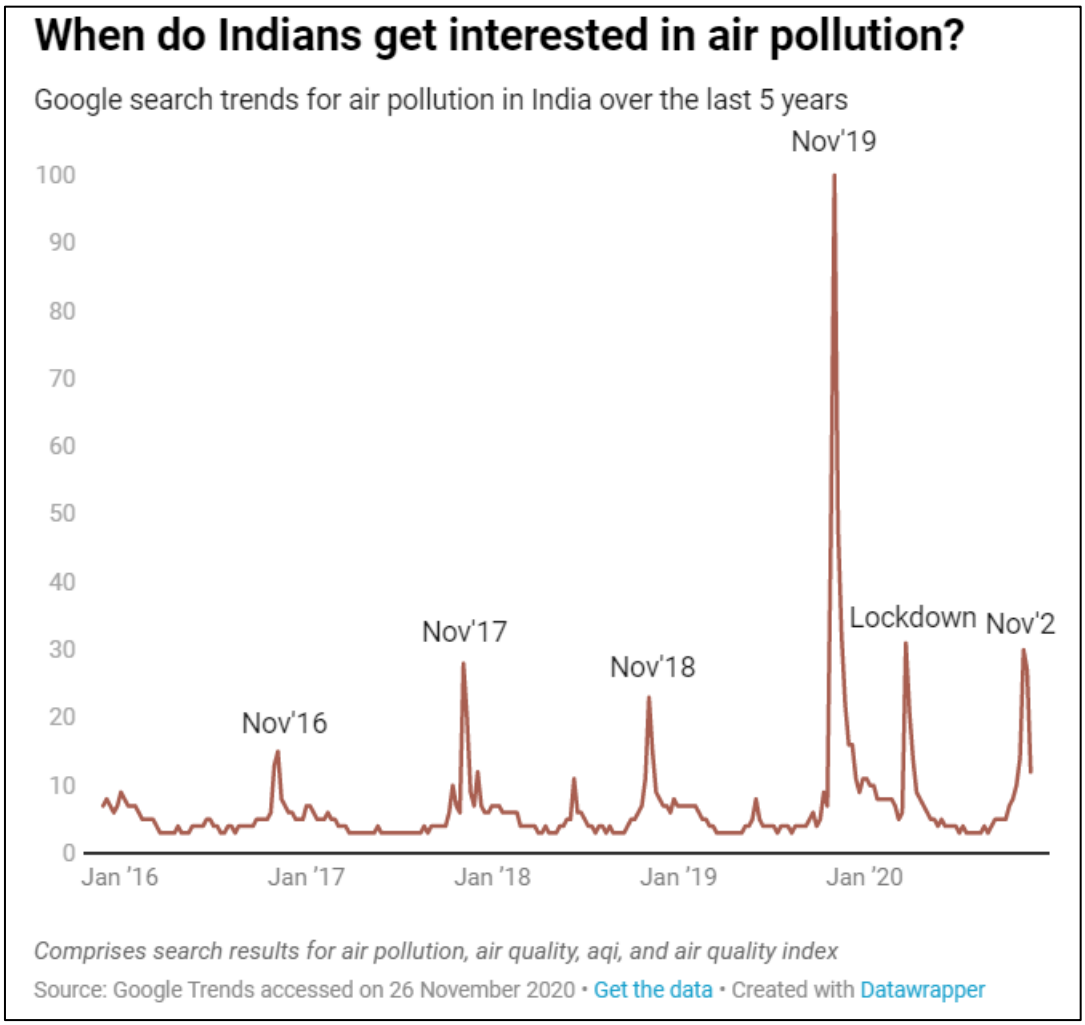
1965
1970
1980
1990
2000
2010
2019
Source: Our World in Data based on BP & Shift Data Portal
OurWorldInData.org/energy • CC BY
Note: Energy refers to primary energy – the energy input before the transformation to forms of energy for end-use (such as electricity or petrol for transport).
1965
2019



Indian government in an effort to curb urban air pollution, has come up with the National Air Quality Action Plan. For the first time government aims to reduce air pollution in a targeted fashion. National Clean Air Programme (NCAP) as a long-term, time-bound, national level strategy to tackle the air pollution problem across the country in a comprehensive manner with targets to achieve 20% to 30% reduction in Particulate Matter concentrations by 2024 keeping 2017 as the base year[2].

While this development is heartening a clearer source by source analysis and strategies need to work in hand with the regional air shed. Current plans look at city level strategies and city level monitoring. The science of air quality is predominantly governed by 2 factors that determine the impact i.e the total ground level ambient air pollutant concentration:

1. Source
2. Meteorology

[2]https://pib.gov.in/PressReleasePage.aspx?PRID=1655203#:~:text=The%20Central%20Government%20launched%20National,2017%20as%20the%20base%20year

Meteorology governs pollutant behaviour.

Atmospheric transport of pollutants comprises of

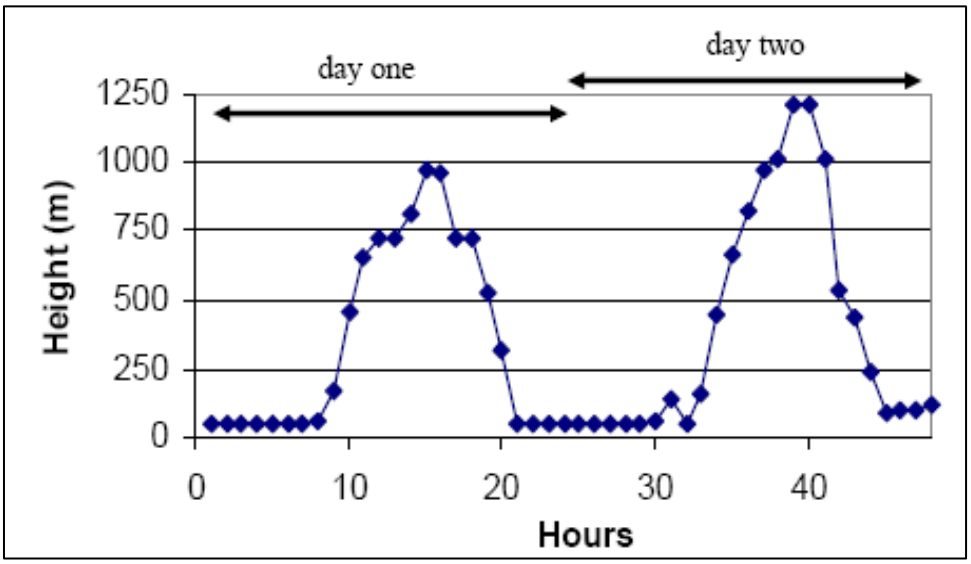
- ***Advection*** (horizontal transport due to wind)
- ***Dispersion*** in the (horizontal and vertical) due to **atmospheric stability**

Ground-level concentrations of contaminants are primarily controlled by two meteorological elements: wind direction and speed (for advection), and ***turbulence*** and ***mixing height*** of the lower boundary layer (for dispersion).

Mixing height:

- Quantitative indicator of atmospheric stability
- It represents the height of the convective boundary layer
- The mixing height or mixing depth is the height to which the atmosphere is uniformly mixed
- Height is the first elevated inversion is taken as mixing height

Mixing height is a function of time of the year (season), time of the day and the local topography and setup(urban/rural). It show diurnal and seasonal variation and is function of location.



Source: Radiosonde measurements taken during winter in Patalganda air shed.

Winds in a particular air shed is impacted by surface roughness i.e the type of elements that impede the flow and topography (eg coastal, or valley or vicinity of hills). This therefore is a typical determinant of the air shed. Hence a town which is in a valley may experience intense pollution episodes as opposed to a coastal region. Typically a urban area with higher buildings and streets with high rise may experience street canyon effect and wind tunnelling. The dispersive characteristics of

the atmosphere are different over large urban areas, which might have significant surface fractions of concrete, roads and buildings. Height and spacings of buildings thereby influence the wind turbulence.

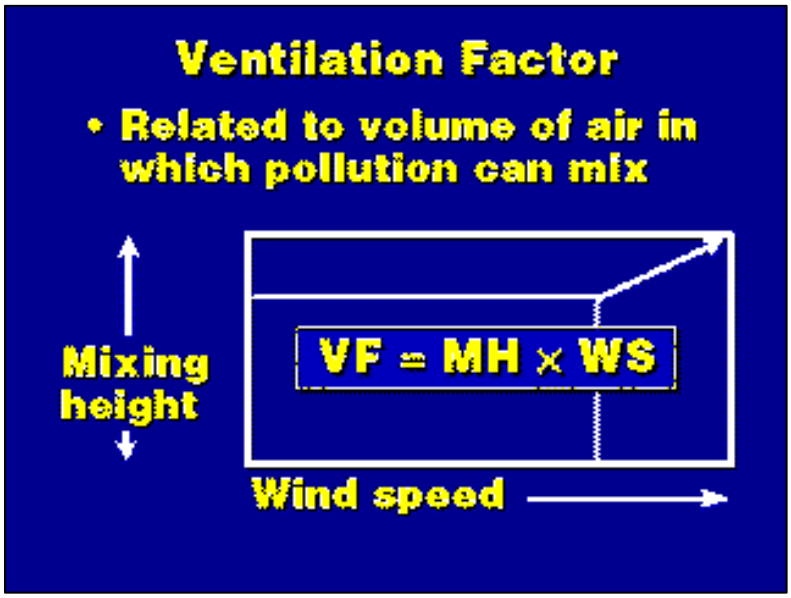
Another important aspect is the parameter temperature. Variation of temperature with height in atmosphere is called the lapse rate. Typically the temperature reduces with height. However at night and early mornings temperature increases with height. This therefore is inherently stable causing cool air to descend and a formation of a layer known as inversion layer. Temperature inversions are caused by a number of different mechanisms. Surface or ground-based inversions often occur on clear, cold nights when there are low wind speeds. Under these conditions the ground cools more quickly than the air immediately above it, causing a pool of cooler, more dense air to accumulate at ground level. Inversion layer – in which the temperature increases with height. Elevated inversion traps the pollutant like a lid. Duration of inversion and frequency of occurrence is critical for dispersion. The height up to which pollutants can mix is therefore critical in dispersion.

Understanding urban heat island effect

- "Urban Heat Island" (UHI) refers to the tendency for a city to remain warmer than its surroundings.
- This effect is caused mostly by the lack of vegetation and soil moisture, which would normally use much of the absorbed sunlight to evaporate water as part of photosynthesis (a process called "evapotranspiration").
- Instead, the sunlight is absorbed by manmade structures: roads, parking lots, and buildings. With little or no water to evaporate, the sunlight's energy goes into raising the temperature of those surfaces.
- After the sun sets, the city is so warm that it never cools down as much as the countryside around it, and so retains the heat island effect all night long.
- Due to the temperature difference between the urban and rural areas there is a formation of urban elevated inversion layer over the urban region.
- This prevents the pollutants from getting dispersed as it acts as a lid.

If one were to get an idea of the ability of an air shed to abate pollution – one would typically look at ventilation coefficient.

It is a combination of Mixing height and wind speed and signifies the ability of the air shed to deal with pollution.



High pollution potential zone is defined as a meteorological condition which given the existence of emissions would be conducive to poor air quality. This is stated in meteorological condition only and are deliberately restrictive.

The ventilation coefficient can be categorised into the following zones:
<6000 m2/s – High pollution potential
6000 – 12000 m2/s Medium
>12000 m2/s – low

The criteria for forecasting high pollution potential are early morning or late evening especially during winter season when mixing heights are very low and wind speed , 4m/s. Typical differences in summer and winter incoming solar radiation determine dispersion capacities.

Ventilation coefficient is highly site specific (depends on the topography). It is also diurnal and seasonal. Trend analysis of long term mixing height data reveals that maximum mixing height reaches peak value (and hence low pollution potential) and minimum (and hence high pollution potential) during winter. In order to predict pollution potential NAQM needs to integrate meteorological data along with AQI.

Ventilation Coefficient can be used along with AQI to warn residents as well as to prevent episodes of garbage burning/crop burning during adverse weather conditions. Focussed regulatory warnings

and strict action on urban air polluters governed by scientific understanding of seasonal and topographical effects of air quality can result in attainment of the air quality targets set by NAQM. Ventilation coefficient is a great indicator of natures ability to handle the emission load in the air shed. Abatement plans for an air shed must take into account the following aspects for stronger implementation and prioritisation of local clean air strategies.

Combined with knowledge of contribution of sources and the pollution potential of the air shed will bring sharper focus to the action plans. Contrary to the current city based action plans, the air shed/pollution potential approach helps in addressing sources that are not in the city but are the periphery – typically the boundary of urban and rural outside the city limits.

Another aspect that needs to be considered, just as air shed has its characteristics, sources in a region are characteristic of the activities in the air shed. Hence action plans must focus on prioritising based on

1. Sources of pollution
2. Pollution potential

Therefore, similar action plans across cities may not work due the above reason. Since pollution abatement is a function of cost effectiveness – tying it to natures pollution abatement capability may help in taken informed cost effective abatement decisions. Urban local bodies can, therefore, effectively avoid air pollution episodes by laying out strict warnings based on local meteorological conditions. This article explores the possibility of mainstreaming ventilation coefficient in management of air quality containment zones and integrating it into air quality action planning.

Improvement to Air quality of Railway Stations in India

*Vinayak Padalkar **

Abstract

Rapid urbanization is a major change taking place in India. One of the major causes of concern is poor air quality in urban areas. Especially at the areas of access to public transit viz., railway stations, metro stations, bus terminals. Road vehicles are the major contributors to the poor air quality at entry and exit points of railway stations. There premises often have poor management of traffic, dilapidated roads, pavements encroached by retailers and motorist lead to vehicles typically undergoing long idling, acceleration and deceleration there. Moreover, these areas are typically crowded leading to higher exposure risk to SOx, NOx, CO and PM. The problem of air pollution at Indian Railway stations can be solved by passive and active mitigation methods. Proper planning and segregation of road vehicles in and around railway premises and upgrading of infrastructure proves vital in free flow of traffic and acts as passive method of air pollution management. The areas which have high rise buildings in close vicinity pose a unique challenge. The high-rise buildings increase the concentration of the pollutants near the source by hindering the process of its dispersion. This effect is also known as " Urban Canyon Effect." Increasing dispersion of pollutants by mechanical means and stripping the pollutants from the air using technology serves as active air pollution mitigation method. Circulating area of Indi Road Railway station which is in Indi Tehsil of Vijayapura District of Karnataka was developed to ameliorate air quality in the area. As a part of this project, residential blocks were shifted to new location having lower exposure risk. Exclusive lanes were provided to vehicles for passing through the premises, to pick up and drop and to commercial motorist. Parking spaces were provided near to the station premises. Remaining area was developed into enclosed gardens and green patches to prevent it from encroachment. All these measures led to significant improvement in air quality of the area.

Introduction

Urban air quality is a matter of concern all over the world. According to Census 2011, about 377 million Indians comprising 31.14% of the country's population lived in urban areas. As per the figures published by Ministry of Urban Development, Government of India in Handbook of Urban Statistics 2016, the urban population is projected to grow to about 600 million (40%) by 2031 and 850 million (50%) by 2051. High population exodus to the urban centres, unsatisfactory public transport system and poor land-use management are some very common problems faced by India.

*** About the Author:** *Mr. Vinayak Padalka is an Indian Railway Service of Engineers (IRSE) officer of 2014 batch. Currently working as Senior Divisional Engineer, Hubbali in Hubbali Division of Indian Railways. He is responsible for upkeep and development of Railway infrastructure adding to 435 route km which includes 68 stations, 623km track, bridges, level crossings and other assests.*

Adulteration of fuel & fuel products, improper traffic management system, poor road conditions, inadequate awareness about the air quality and lack of capital for implementation of programs for air quality improvements are some of the key issues which are responsible for deterioration of urban air quality (CPCB, 2010).

The National Environmental Engineering Research Institute (NEERI) in its detailed report (2010) states that many places where air quality monitoring was carried out in Mumbai, has very poor air quality. Major contributor of many of the key pollutants such as CO (30-35%), PM (20-30%) NOx (35-70%) was from vehicular traffic. The proportion of their contribution varied according to site conditions and other physical and meteorological factors. In areas of access to public transit viz., railway stations, metro stations, bus terminals, road vehicles are the major contributors to the poor air quality. Due to poor management of traffic, dilapidated roads, pavements encroached by retailers and motorist lead to vehicles typically undergoing long idling, acceleration and deceleration there. This leads to increased emission of air pollutants. Moreover, these areas are typically crowded leading to higher exposure risk.

Air pollution in urban areas is a major issue

Urban air quality issues have emerged as a major concern impacting quality of life. The high disease burden due to air pollution has started to impact the economy of the urban centres. Outdoor PM air pollution is estimated to be responsible for about 3% of adult cardiopulmonary disease mortality; about 5% of trachea, bronchus, and lung cancer mortality; and about 1% of mortality in children from acute respiratory infection in urban areas worldwide. This amounts to about 0.80 million premature deaths and 6.4 million lost life years. (Cohen et al., 2005). Gurjar et al. (2010) carried out a study to evaluate the health risks in megacities in terms of mortality and morbidity due to air pollution. A spreadsheet model, Risk of Mortality/Morbidity due to Air Pollution (Ri-MAP), was used to estimate the excess numbers of deaths and illnesses. Results suggested that some megacities like Los Angeles, New York, Osaka Kobe, Sao Paulo and Tokyo had a very low excess cases in total mortality while the approximate numbers of cases were highest in Karachi (15,000/year). Dhaka (7000/year), Beijing (5500/year), Karachi (5200/year), Cairo (5000/year) and Delhi (3500/year) ranked highest with cardiovascular mortality. Monetary burden for morbidity due to air pollution was calculated for the city of Mumbai. The total monetary burden of health impacts, including personal burden, government expenditure and societal cost, was estimated at 4522.96 million Indian Rupees (INR) or US$ 113.08 million for a 50 μg/m3 increase in PM10, and INR 8723.59 million or US$ 218.10 million for a similar increase in NO2.

Factors affecting pollutants' dispersion

The local wind flows inside the street canyons is a strong function of the street geometry and traffic induced turbulence. A slight change in the wind direction with respect to the street has significant effect on the wind flow pattern and the pollutant concentration profile (Soulhac et al., 2009). Dispersion of gaseous pollutants in street canyons takes place under the joint influence of natural and vehicle-induced air motions. During 'calm' wind conditions, the turbulence produced by the moving vehicles is dominated over the natural winds in the street canyons (Solazzo et al., 2008). Increase in the rate of reduction in pollutant concentration increases with in approaching wind angles with maximum concentration reduction found at 60° approaching wind direction. It is due to generation of larger size eddies by moving traffic resulting into more dilution.

Air pollution control and minimizing exposure risk

The problem of air pollution at Indian Railway stations can be solve by passive methods and active control methods. Proper planning and segregation of road vehicles in railway station premises improves free flow of traffic and reduces emission due to idling, acceleration and deceleration cycle. Upgrading of road infrastructure also proves vital in free flow of traffic and acts as passive method of air pollution management. The areas which have high rise buildings in close vicinity poses a unique challenge. These high-rise building increases the concentration of the pollutant near the source by hindering the process of dispersion of the pollutant. This effect is also referred as Urban Canyon effect or Street canyon effect. Increasing dispersion of pollutant by mechanical means and stripping the pollutants from the air using technology serves as active air pollution control method.

Reducing the emission of air pollutants in the open ambient atmosphere is necessary for good air quality. The most promising method to reduce emission from vehicular traffic is by adopting scientific techniques in traffic management. Many cities all over the world has adopted Active Traffic Management (ATM) system to reduce the traffic congestion and thereby reducing emissions. According to a report of Federal Highway Administration, US Department of Transportation, Active Traffic Management is a system which has ability to dynamically manage recurrent and non-recurrent congestion based on prevailing traffic conditions. This technique of traffic management is been implemented in various countries including Germany, United States and United Kingdom. A transparent bioreactor is made long the roadside in Geneva, Switzerland. This bioreactor contains algae which consumes CO2 emitted by vehicular traffic in presence of sunlight and converts it into oxygen by the means of photosynthesis.

A paint is been developed in Philippines which reduces NOx in the ambient air. This paint contains photo-catalytic titanium dioxide, (TiO2), which upon exposure to light, transforms ordinary water vapour to free radicals that break down NOx and volatile organic compounds (VOCs), the two components of smog. Harmful NOx gas is converted to nitric acid that is rapidly neutralized by alkaline calcium carbonate particle in the paint, producing harmless quantities of calcium nitrate and negligible amounts of carbon dioxide (CO2) and water.

Case study of Indi Road Railway station

Indi Road Railway station is in Indi Tehsil of Vijayapura District of Karnataka. This Railway station serves primarily to the passenger traffic of Indi town and adjoining rapidly growing villages. Recurrent traffic congestion was observed in the station premises of Indi Road Railway station as Indi- Lachyan State highway passed through the railway premises. This led to traffic congestion between vehicles leading to Railway station and vehicles of state highway. Acute shortage of space in railway premises for vehicles of railway users leading to unplanned parking over the existing road leading to situation of disruption in traffic. Moreover, vehicles stopping over the road for pick and drops of Railway users made the traffic conditions worse. The residential blocks of railway staff were situated in front of station very near to the station entrance. This left them highly exposed to the pollutants emitted by the vehicular traffic. Moreover, these buildings left very less scope for widening of the road. Intermingling of pedestrians and vehicular traffic led to further aggravating traffic woes and hugely increasing pollutant exposure.

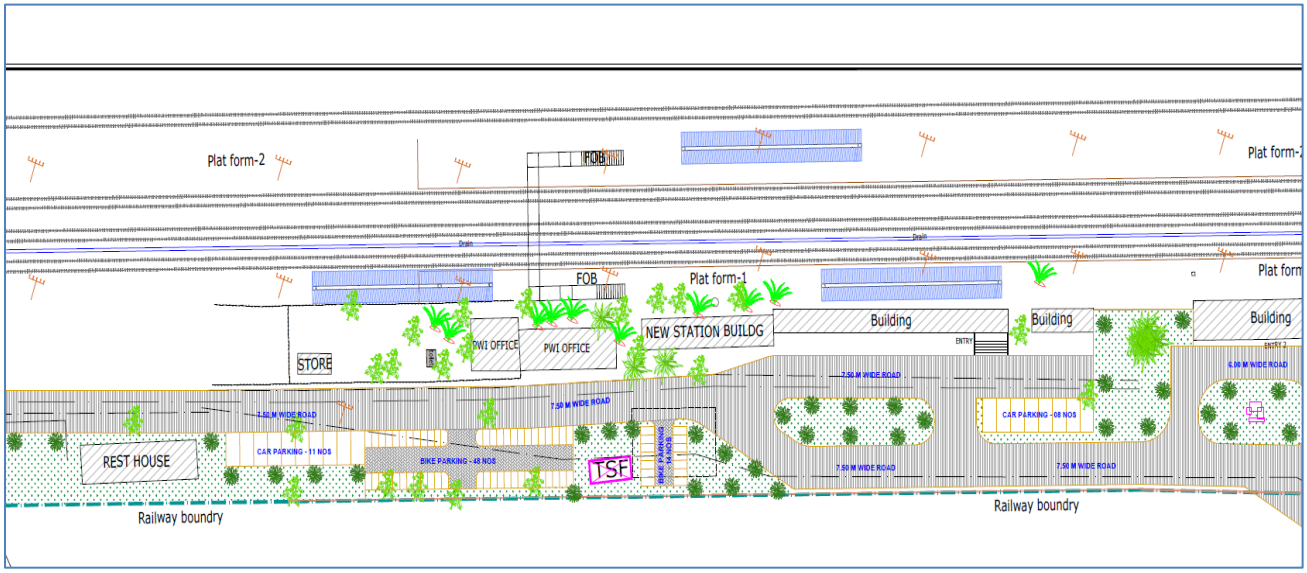


Figure: Development plan of circulating area of Indi Road Railway station

Circulating area of Indi Road Railway station was taken up to ameliorate air quality in the area. As a part of this project, residentials blocks were shifted to new location with lesser exposure risk. Exclusive lanes were provided to vehicles for passing through the premises, to drop and go and to commercial motorist. Parking spaces were provided near to the station premises. Remaining area was developed into enclosed gardens and green patches prevent it from encroachment. This led to significant improvement in air quality of the area.

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Blending Biofuels with Fossil Fuels for Sustainable Energy in India

Sujata Bhaker *

Abstract

India has 17.84% of the global human population but occupies only 2.4% of the global surface area and possesses only about 6% of the world's primary energy sources. The world's conventional energy reserves are dwindling and, hence, there is an urgent need to find alternatives to fossil fuels. Speculating the looming energy challenges, Indian policymakers have taken multiple strategic steps to incorporate renewables into the energy systems. Biofuels have emerged as a renewable, reliable, and green source of energy and their demand for blending in transport fuels has increased globally. Biofuels could help in enhancing the energy security of a nation and minimizing dependence on imported crude oil. Towards this endeavor, the Government of India has initiated the Bioethanol Blending Programme (EBP) with a 5% blending target in the year 2003 and scale up to 20% by 2017. This study identifies that to achieve the blending targets, India needs to work on the entire supply and value chain, i.e., from securing raw material to building infrastructure to create a conducive market and pricing mechanism for EBP. However, the major bottleneck that has the potential to jeopardize the program is the lack of infrastructural facilities. The country needs to install 43 and 88 new distillation facilities during 2017 and 2030. A Life Cycle Assessment (LCA) study was performed to identify the environmental impacts of these newly identified locations and compared them with the other two possible scenarios. The results showed that, for one ton of bioethanol production, the overall GHG emissions in Scenario 1 (ethanol production at newly identified location) was 913 kg CO2-eq, which is 2% higher (820 kg CO2-eq) than that in r scenario 2 (ethanol production at sugar mill with integrated distillation) and 26% lower (1230 kg CO2-eq) than that in scenario 3 (ethanol production at refinery unit). The study not only quantified the GHG (Greenhouse gas) emission, energy consumption, and impact on the health during the ethanol blending process but also generates data to underpin the bioethanol policy formulation in the country.

1. Introduction

In 2009, the Indian government adopted National policy on biofuels and set the target of 5%, 10%, and 20% blending target in a phased manner by 2005, 2010, and 2017 respectively (Ministry of New and Renewable Energy 2009). India managed to blend only 3% of fuel by 2017. Post-COP 21, Indian policymakers revived the Ethanol blended fuel mission and set the timeline to achieve a 20% fuel blend by 2030 (ET Bureau 2017). So, the current study, have aligned their research work for 2030 fuel demand and timeline.

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India has about 526 sugar factories that typically produces 24-26 million tons of sugar and 10-13 million tons of molasses as a by-product from the year 2010-16 (Figure 1). In the year 2014-15, 362.33 million tonnes of sugarcane were produced and this was the maximum sugarcane producing year in the last ten years (Commission for Agriculture Cost and Price 2016). So, the current study has analyzed the status of the ethanol production potential of the country for the year 2014-15 and 2030-31(Solomon 2016; Ministry of Agriculture and Farmers Welfare 2017).

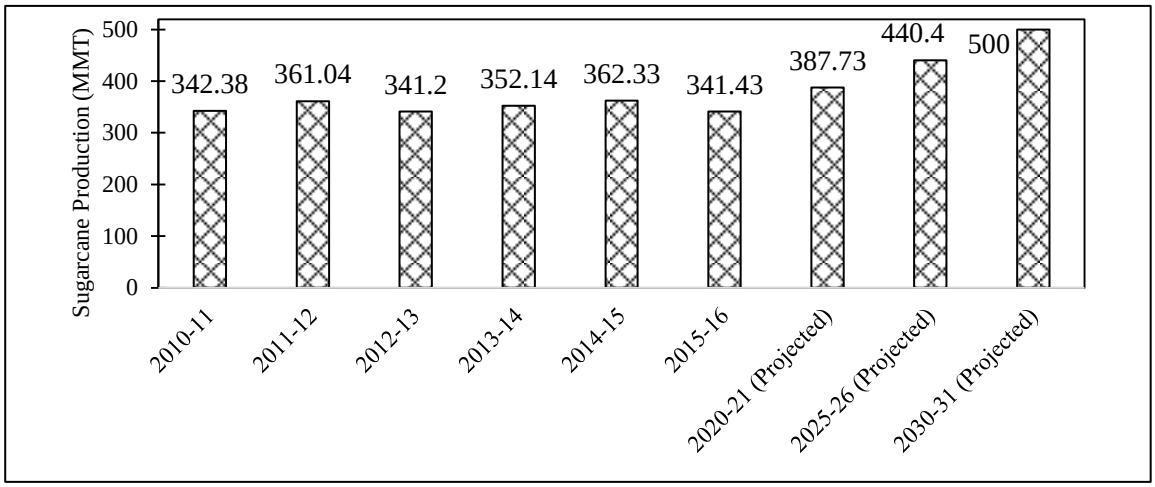

Figure 1: Sugarcane production in India, 2011 to 2031

2. Status of Ethanol Blending Program

India is aiming to blend 20 % of its fuel with ethanol by 2030. As of now, around 100% of the feed for ethanol production comes from the sugar industry in the form of molasses. This feed (molasses) is fermented and distilled to produce ethanol. So, the current study had identified the existing industrial and market linkages along the supply chain of EBP and assessed the status of the present capacities in each of the associated stream, i.e., Sugar industries, Fermentation & Distillation industries, and Ethanol market as shown in Figure 2.

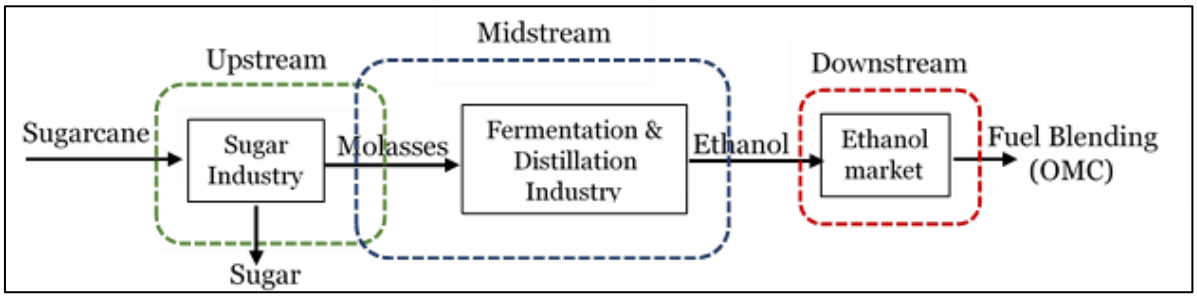

Figure 2: The supply chain for ethanol blending in India

2.1. Ethanol supply chain analysis

The analysis performed a reality check on the government's vision to blend 20% of the gasoline fuel with ethanol by the year 2017. Further, the quantitative analysis of all the streams showed that it is possible to blend only 3% fuel in the year 2014-15 (base year), and even in most optimistic scenarios, it cannot be more than 11%. This study identified that to achieve the blend target, India needs to work on the entire supply and value chain, i.e., from securing raw material to building infrastructure to creating a conducive market and pricing mechanism for EBP. However, the major bottleneck that has the potential to jeopardize the program is the lack of infrastructural facilities (Figure 3).

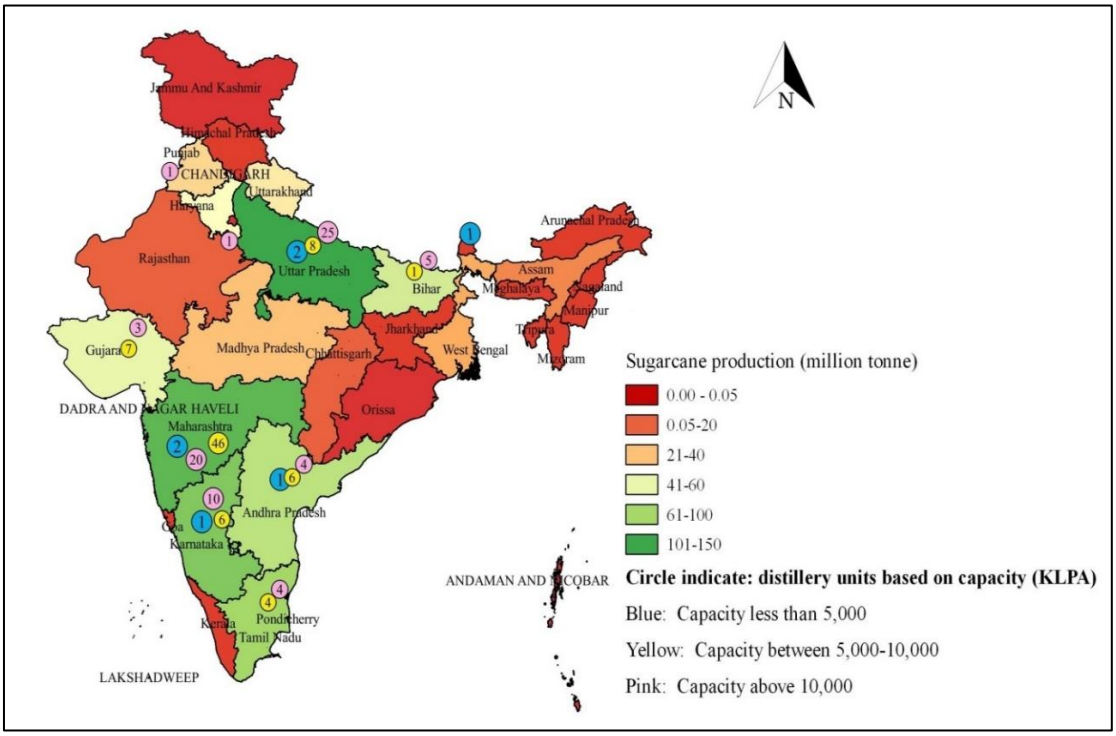

Figure 3: Statewise ethanol production unit and sugarcane production

3. New location and LCA analysis

This analysis was executed for two years, i.e., base (2014-15) and projected (2030-31). For both years, existing infrastructures, i.e., 526 sugar mills and 162 distillation facilities, have been considered (Indian Sugar Mill Association 2016a, b). The molasses generated from the sugar mill was allocated to the nearest distillery for ethanol production. The unprocessed molasses from each sugar industry were quantified and analyzed. In the base year, out of 526 sugar mills, 98 sugar mills require 43 new facilities to process the available unprocessed molasses) in the different states of the country. Similarly, in the year 2030-31, 156 sugar mills were identified, which will require 88 additional infrastructure to produce ethanol from surplus molasses. New locations have been identified using spatial analysis by the GIS tool (Andy 2005).

3.1. LCA study for Ethanol Supply

LCA study considering Well-to-Tank (i.e., production and transportation) approach has been conducted based on the guidelines of ISO series 14040 and 14044 (ISO 14040 2006; ISO 14044 2006). The study was set to compare the potential environmental impact of the bioethanol production route from molasses (a by-product from sugar industries) at new processing locations (scenario 1) and compared with the two different possible scenarios (scenarios 2 and 3). Scenario 2 considered the molasses processing at an integrated facility (sugar industries with distillery) and scenario 3 assumed that all the available molasses would be processed and blended both at the refinery unit.

The result for 1 tonne of bioethanol production, the GHG emissions of Scenario 1 was 913 kg CO2-eq, which is 2% higher (820 kg CO2-eq) from scenario 2 (ethanol production at sugar mill with integrated distillation) and 26% lower (1230 kg CO2-eq) compared to scenario 3 (ethanol production at refinery unit) (Figure 4).

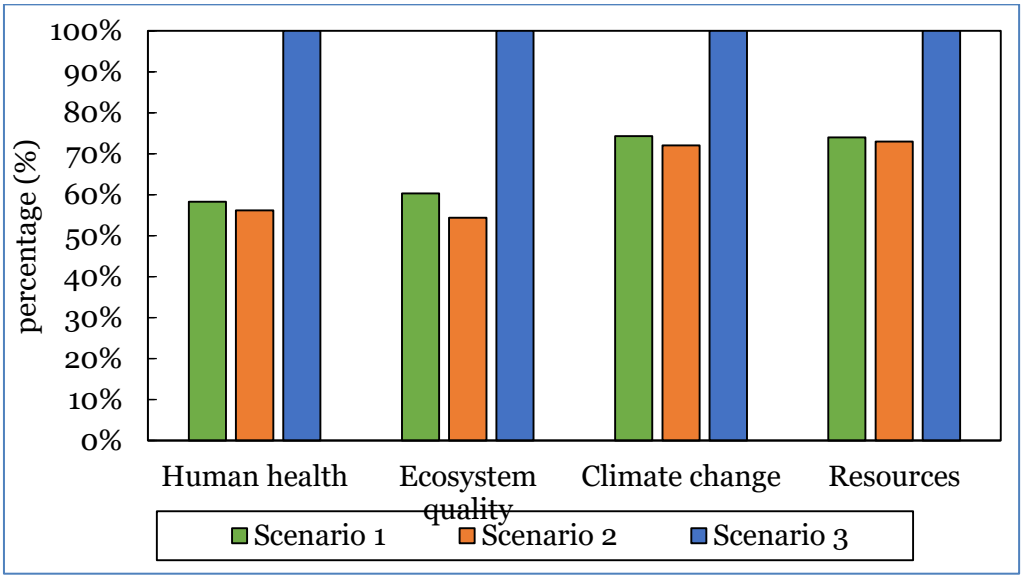

Figure 4: Comparison of Damage category impact of Scenario 1, 2, and 3

This study quantified that scenario 2 is contributed 1% to 6% less impact among all the impact categories compared to scenario 1. It is also important to note that on a national scale, only 1/3rd of the total sugar mills have integrated distillation facilities. The Indian sugar industry has 60% of the mill at a small scale with crushing capacities to handle around 2500 TCPD. It is not a feasible option for all the sugar mills to set up an integrated facility for ethanol production. Scenario 3, which contributes to the maximum impact among all the impact categories, is the least feasible option.

4. Conclusion

This study has investigated different streams along the Molasses-to-Ethanol supply chain to perform a reality check on the government vision to blend 20% of the gasoline fuel with ethanol by the year 2030. The analysis showed that India needs to work on the entire supply and value chain i.e. from securing raw material, to building infrastructure to creating a conducive market and pricing mechanism for EBP. The newly identified infrastructure should be considered for a new distillation facility because these new strategic locations will not only contribute to meeting the blending target but also support India's commitment to reduce its carbon intensity by 2030.

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Air Pollution Managment in Urban India

*Vinod Kumar and Sangeeta Sharma**

Abstract

Most Indian cities are plagued with chronic air pollution and its prolonged exposure has detrimental effects on our health. It is well established that air pollution causes respiratory, skin and several other ailments. High levels of air pollution might also be responsible for increasing COVID-19 infections in the country. Therefore, air pollution abatement measures are now much more important than earlier. While concerned authorities are already enforcing some of these measures but stringent implementation and enforcement of norms to prevent uncontrolled burning of various forms of biomass and accelerating the use of sustainable clean energy are still required. For a tangible reduction in air pollution problems in the country, involvement of all stakeholders, including government authorities, civil societies and citizens, is crucial. Lack of public participation in environmental protection could be attributed to low levels of awareness and civic sense in the country. In view of this continuous efforts are required to enlighten people about the detrimental effects of air pollution.

Intoduction

Recently, there has been a lot of concern and ensuing deliberations on the high levels of ambient air pollution in Delhi and other urban areas of India. This has prompted various authorities to propose some quick-fix solutions. In Delhi, for example, some of these proposals include permitting cars with odd/even numbers on alternate week days, entry of trucks during the night hours only, pollution cess on diesel-run trucks entering Delhi, discarding vehicles which are more than ten years old, etc. However, while some of these steps may provide a temporary and very limited relief, if any in the short term, they are inadequate and, therefore, may not yield the desired results for a long term permanent solution for air pollution abatement in Delhi, Mumbai and other cities in India due to the following reasons.

The first and foremost requirement to address air pollution at any given location is to correctly identify all major sources contributing to the pollution at that location. This is a complex exercise, which needs to be done regularly and cannot be quick-fixed by temporary measures as above. By focusing on cars and vehicles, authorities seem to have identified these as the major sources of pollution in Delhi.

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In contrast, several studies on source apportionment conducted over the past 25 years suggest that the major contributors (even upto 40 per cent) to pollution of particulate matter (PM) are unknown sources, which may include natural dust and anthropogenic emissions from some fugitive sources

Air pollution is a transboundary issue and it cannot be contained within the boundaries of a city, state, or even nation. Being site-specific, the severity of air pollution at any location depends not only on sources around the location but also on the atmospheric conditions, viz., wind velocity and direction; temperature and pressure. In Delhi, the high concentration of pollutants, most of the time, are thus, associated with the West and South-West to North-West directional winds. Owing to its geographical location, the city of Delhi has mostly remained plagued with air pollution issues as it is prone to poor air quality due to emissions from all directions, including natural dust and man-made pollution from other states. These are the main reasons that the PM pollution in Delhi is often observed to be 50 to 100 per cent higher than Mumbai and other metros.

There are extensive agricultural activities, both within Delhi and its surrounding states, which contribute to air pollution through burning of agricultural wastes in the fields. Needless to mention, a large number of families, above 35 per cent in urban areas and as high as 75 per cent in rural areas, still use polluting fuels, such as wood, coal, cow dung and agro-waste, for their household chores. In addition, indiscriminate open burning of anything, including waste on dump sites, is rampant in and around the city. Further, pollution from micro scale plants and cottage industries often remains unidentified. All these sources are associated with high emissions of PM and, hence, need to be accounted for in terms of their share in air pollution.

Since some natural emissions may be masking the effect of anthropogenic emissions in Delhi, it is essential to investigate the net effect of various man-made activities. Further, it is not only necessary to segregate natural and anthropogenic pollution, but also to apportion the pollution among various man-made activities and identify the major and minor sources amongst them.

It is to be noted that the above arguments in no way justify that vehicles are not a major source of air pollution. They are certainly a major source in all urban areas, but their contribution to PM pollution, based on which the redressal decisions are proposed in Delhi, may or may not be so significant. Particulate pollution is site specific, which has also been established earlier by many studies conducted for Delhi and other cities. Thus, contribution of vehicular emissions to PM pollution may be different at various locations within the same city. Even among all vehicles, which type of vehicle is the major polluter, needs clarity. Hence, in the absence of research based scientific investigations that clearly link vehicular emissions to PM pollution, targeting only cars and trucks is not the right strategy. An undue focus on these vehicles, if they are not major contributors to PM pollution, may

not lead to significant reduction in air pollution levels. On the contrary, it may result in waste of financial and other resources. Also, based on the past experience of similar interventions to control air pollution, viz., replacing diesel with CNG in vehicles, introduction of PUC, introduction of various "Bharat Stage Standards," etc., there is a possibility that the above measures, including "odd/even car policy in Delhi," may not be so effective; instead it may only cause undue inconvenience to people.

The decision of using economic instruments such as imposing an "Anti-pollution Cess" on trucks entering Delhi may not be very appropriate, if not enforced and monitored systematically. The polluting trucks can enter the city by paying the cess, and thus, will still contribute towards further deterioration of the air quality. There is also the possibility that a truck loaded with some polluting material, e.g., loose building material, may pass under disguise of carrying essential commodities, with or without knowledge of enforcing authorities.

Further, even if we are able to restrict all trucks on the periphery of Delhi, their emissions, depending upon the wind direction, would still contribute to air pollution in the city. Similarly, "Night-entry plan" for trucks and other commercial vehicles is highly undesirable as it may create dangerous levels of photo-chemical smog in the mornings due to large emissions during night and photo-chemical reactions coupled with temperature inversion in the morning hours.

Further, without an effective monitoring mechanism, the enforcement of some of these measures will be an uphill task. For example, how would we enforce the norm "Fine of Rs 5000 for open burning?" If there are not enough enforcement measures, people may bypass the law until they are caught red handed. Even if they are caught burning the waste, they may prefer to a pay a lesser amount dubiously to the enforcement agencies thereby encouraging corruption and augmenting levels of air pollution.

Socio-economic conditions of most of the car/ vehicle owners in India will make it difficult to implement norms such as "discarding a 10 year old car/ vehicle" until there are significant incentives provided by the government or auto manufacturers to the users. Also, it is not the age of car/ vehicle but quantum of emissions from it, which is responsible for air pollution and it depends on the car's/ vehicle's mileage, frequency of its use and its maintenance. With "age of the vehicle rule for all," we may unknowingly penalise those consumers, who either due to economic or any other reason, use their cars/ vehicles sparingly. For example, most of those living within the residential campus of an educational, IT or similar organisations either due to their environmental awareness or due to proximity to their workplace often use their vehicles for only few hundred kms per year. Expecting a 10 year old diesel car to be scrapped, inspite of having a total mileage of say, around 5000 kms is

unreasonable. Further, such cars from Delhi and other cities, along with their presumed polluting characteristics, may shift to smaller towns and, thus, this rule will only displace pollution and increase an overall pollution at national level. A comparison of car ownership indicates that cities in the developed world have much higher car ownership than those in developing countries. For example, the number of cars per 100 persons is 56 in Melbourne, 30 in London, 21 in New York, 18 in Tokyo, while, in Delhi it is only 5 to 6 and in Mumbai 2 to 3 cars per 100 persons. In fact, Mumbai is one of the cities in India where pollution levels are above their prescribed limits on 35-40 per cent days of the year.

On the other hand, in some much smaller towns such as Jaipur and Lucknow, having much lower number of cars than metros, pollution levels are above these limits on more than 90 per cent of days of the year. All these figures indicate that number of cars and vehicles are not the only indicators of high levels of air pollution in Delhi, Mumbai and other urban areas. Further, by restricting number of cars on the road but, at the same time, introducing more number of auto-rickshaws, taxis, etc., will neutralise any reduction in air pollution levels, which, if at all, may be due to limiting the number of cars on the roads. Travelling by autorickshaws and two wheelers may also have an adverse effect on health of people as it increases our exposure to air pollution upto 2 to 3 times as compared to travelling in a closed transport vehicle like bus or car.

Hence, most of the measures suggested by the authorities are only short term and inadequate and these may not address the air pollution issues in Delhi, Mumbai or any other Indian city effectively and on a long term basis. So what is the solution then? In this regard, we should not follow other countries on a general basis and suggest impractical measures. We may consider the following for an India specific solution. As mentioned earlier and, it is also evident from variable levels of air pollution reported at various monitoring locations of CPCB in Delhi, air pollution is a site-specific phenomenon.

Since pollution sources are site- specific, the measures to tackle pollution at any location should also be site-specific. Hence, "one size fits all" formula may be ineffective for all cities or even for all areas within a particular city. The estimation of source contributions to air pollution, using emission rates from various sources, will neglect emissions from natural and unknown sources. Thus, ambient air pollution levels at a location, which are the actual levels to which people are exposed, may not be the same as the sum of emissions from all sources estimated using this method. Therefore, contributions to pollution from various sources at a specific location needs to be estimated through source apportionment (SA) studies, which give a better picture of major and minor sources of pollution at a particular location. These studies estimate the contribution of all major sources by

using actual air pollution data monitored at that location. In the past 25-30 years, several SA exercises have been conducted for Indian cities including Delhi and Mumbai. Unfortunately, instead of being a regular exercise and a decision making tool they have been conducted either for academic purposes or sort of a symbolic action taken up by the concerned authorities in collaboration with academicians and researchers.

Thus, it may be necessary to conduct the SA studies frequently to see the changes in pollution at various locations vis-à-vis the share of contributing sources at those locations. The results of these SA studies should be used to first segregate the share of pollution from natural and anthropogenic sources to know the net contribution from all major man-made sources. Further, it is possible to apportion the pollution from all man-made sources and ascertain the major and minor anthropogenic sources. Once, we are able to identify the share of pollution from major man-made sources, we can then focus and implement appropriate remedial measures, accordingly.

A large portion of the population in Delhi and other Indian cities still do not have access to electricity and other forms of clean energy for domestic chores. Such households must be provided the same in order to avoid use of traditional biomass and other polluting fuels. The central government schemes of extending the LPG facility and provision of electricity to all families need to be accelerated as such steps will make a significant reduction in air pollution due to domestic biomass burning. Sustainable energy options, viz., biogas, waste-to-energy, etc., are not only less polluting, but will also go a long way in an effective waste management.

There is an urgent need to increase the use of vehicles powered by various forms of renewable energy, such as, batteries, solar power and those using less polluting liquid fuels. About ten years ago, there was an impetus for the promotion and use of biofuels such as biodiesel and ethanol, which needs to be accelerated once again. Research in clean technology and fuels should be enhanced so that some indigenous technology can be developed that may help reduce the levels of air pollution. Until we are self-sufficient in developing our own technologies, we could even import such technologies or vehicles from countries that have successfully used them to reduce their local air pollution. Simultaneously, we may also think of promoting the use of bicycles and cycle-rickshaws and construct safe routes for them along the roads and footpaths.

Low levels of awareness and education, lack of civic sense, resistance to change and "not in my backyard attitude" of people are the most paralyzing issues for deteriorating condition of environment in the country. People often complain about the inappropriate and inadequate government measures but hardly change their own life style or contribute to improving the conditions in their own neighbourhood. For example, throwing garbage in the open and its

indiscriminate burning cannot be addressed by mere governmental measures such as fines and penalties; it also requires effective cooperation and willingness of the people to bring about the change. Recently, the media has played a major role in highlighting the benefits of "Swachh Bharat Abhiyaan." Thus, education and awareness of masses needs to be increased to enlighten people about the detrimental effects of polluting activities on their health and society.

Prior to adopting some short term remedial measures, such as use of odd/ even cars, car-pooling and restricting number of car registrations, etc., authorities may ascertain the quantum of positive effect of their actions. For a quick assessment, they may consider implementing a "no car day" or "even a no vehicle day" in Delhi. To minimise the inconvenience caused to people, such days may be observed either on a weekend or on a public holiday and may allow emergency and public transport vehicles only. Measuring air pollution on such days and comparing it with that on other days (when all vehicles are on roads), will give a quick, clear and practical idea about the actual reduction in pollution levels, if any, by removing cars/vehicles from roads.

Local air pollution has a direct link with global air pollution, climate change and global warming. If we are able to reduce local air pollution, we will not only reduce its adverse impact on our health and property, but will also contribute to reduction in greenhouse gases resulting in enhanced global warming. In the recently concluded COP-21 conference in Paris, India has already committed to restricting its carbon emissions and abatement of local air pollution will have a significant effect in meeting this commitment.

To conclude, while the measures suggested by various authorities in Delhi may have some marginal and short term effect on air pollution control in the city; for a long term and permanent solution to tackle in Delhi, Mumbai and other urban areas of India, it is necessary to adopt an effective strategy.

As mentioned above, it is essential to identify and segregate the quantum of natural and anthropogenic (man-made) pollution. Also, the quantitative contribution from various man-made sources should be ascertained and, accordingly, the remedial measures should focus on the major sources of air pollution. To repeat, the menace of air pollution cannot be tackled by regulations alone and their strict implementation and enforcement by authorities and cooperation of masses are crucial. This will necessitate involvement of all stakeholders in pollution reduction measures including public authorities, private sector, NGOs and common people.

Book Review: Personal Exposure to Air Pollution

*Milind Kulkarni**

Air pollution is defined as the presence in the atmosphere of air pollutants in such concentrations and for such duration so as to be injurious to human health. In the pursuit of economic growth Environmental Pollution is often ignored. However we are facing disastrous consequences in the form of global warming and climate change. Successive studies have shown high number of untimely deaths due to air pollution. A recent study conducted by the Energy Policy Institute, University of Chicago which converted particulate air pollution into its impact on life expectancy has shown that in the year 2018 life expectancy in the cities of India such as New Delhi, Kolkata, Mumbai, Pune, Chennai and Bangalore can be increased by 11.4, 9.8, 3.5, 3.4, 3.2 and 2.8 years respectively if WHO guidelines are met. This finding underlines the gravity of the problem of air pollution in India. The fatalities due to Covid 19 all over world were significantly higher in cities like New York, Mumbai, London, Paris characterized by high level of air pollution. In Italy also cases were very high in the industrial region of Lombardy. Experts felt that air pollution weakens the respiratory system due to which number of cases are higher in cities affected by air pollution. Thus it is high time that all of us take the issue of air pollution seriously.

This book presents valuable data as well as insights about important aspect of air pollution which is personal exposure. Traditionally the policy makers judge the air quality based on ambient air quality which is measured at very high level from ground. However a realization is gradually emerging that health risk is more associated with personal exposure which is measured near respiratory level of a person using personal samplers. The data was collected during the doctoral research of the author at IIT Bombay under the guidance of late Prof. Rashmi Patil. The air pollutants selected for the study were respirable particulate matter (RPM-PM5) and Nitrogen Oxides. The respondents selected were outdoor workers such as traffic constable, security persons etc. It was observed that average personal exposure to RPM was 330 µg/m3 which is significantly higher than national ambient air quality standards and WHO guidelines. Personal exposure to NOx was assessed in the International study conducted by Harvard School of Public Health, Harvard University in 17 countries simultaneously. This study came out with some interesting results.

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The findings of the study were given wide publicity in national media and even questions were asked in Assembly of Maharashtra State. Different factors which affect the personal exposure such as season, house size, type of fuel used in house, ventilation were studied and statistical analysis such as ANOVA was done to assess the significance of these factors. Health study was conducted with the help of doctors of KEM Hospital Mumbai to assess the correlation between level of air pollution and morbidity and significant correlation was observed. Models were developed to predict indoor air quality from outdoor air quality. Expert system was developed which helps in assessing personal exposure if one knows the ambient air quality of the locality in which the residence is located.

This book contains findings of significant post-doctoral work. Source apportionment of personal exposure was done to assess the different sources which contribute to personal exposure. Lead levels were observed in the blood samples from children in Mulund area of Mumbai, a study which was conducted with University of Georgia, USA. The book contains latest data on air quality in Mumbai. Though major part of data is for Mumbai city, the findings are applicable for all cities. The book will be useful not only to the students and Professors of Environmental Engineering and Science but also to general public and policy makers for important insights and about how to protect oneself from health risk posed by air pollution.

This E- book is published by Kindle Direct Publishing service of Amazon and can be purchased by following the link https://www.amazon.in/dp/B08P25M2Z3 or by directly accessing the Amazon website Amazon.com. ASIN code of the book is: B08P25M2Z3. The book is priced at $ 4.19 USD or Rs. 371.

About the ISEED Events and the IJSI

ISEED (International Symposium on Energy, Environment and Development) is an Event Series on Innovative Research and Action in SEED (Sustainable Energy, Environment and Development) Issues. The objective of the ISEED is to provide a forum for discussion and dissemination of results of various activities, such as research, action oriented work, advocacy, etc., on sustainable development issues. It brings together, the concerned stakeholders, including academicians, researchers, corporate executives and policy makers, associated with the innovative research and action on any aspect of sustainability. In addition to proceedings containing the papers presented at the ISEED events, selected papers are published in an international refereed journal, the IJSI.

Details of the ISEED-2021 are available at http://www.neef.in/seed/

IJSI (International Journal for Sustainable Innovations) is a peer reviewed inter-disciplinary journal that follows the three-pillar approach for sustainability, *viz*., social, economic and environmental. The Editorial Board of the IJSI includes prominent persons from various areas of expertise. The objective of publishing the IJSI is to highlight any innovative approach, research or action by any individual or organization. It focuses on issues related to energy, environment, infrastructure, industrialization, rural development, urbanization, and other development sectors, the consequences of which are the major concerns for a sustainable future.

Details of the publication process in the IJSI are available at http://www.profvksharma.in/IJSI/

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