Assessment of air quality status of twin city Ahmadabad-Gandhinagar, Gujarat, India: A review

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Abstract -This paper reviews the air quality status of twin city Ahmadabad and Gandhinagar, Gujarat, and also highlighted the need for an updated and systematic city-wide emissions inventory in Ahmedabad to improved air quality and future policy measures. Emission Inventory is one of the important scientific tools used to identify and quantify the number of pollutants emitted into the air. The Ministry of Earth Sciences (MoES) and Indian Institute of Tropical Meteorology, Pune (IITM) undertaken a project called System of Air Quality and Weather Forecasting And Research (SAFAR)-Ahmadabad. The study reveals that the transport sector contributes maximum to the emission of $PM_{2.5}$, CO, NO_x, BC, OC, and VOCs. Maximum SO_2 emission comes from the industrial sector whereas windblown dust is the major source of PM_{10} emission. The transport sector and industrial sector are playing a major role in $PM_{2.5}$ emission contributing around 36% and 33% respectively to the total emission, followed by windblown dust (21%). The domestic sector contributes 7% to the total emission in which emission from slum dominates where considerable use of kerosene, wood, and cow dung has been found. Open trash burning and brick kilns contribute 3% to the total emission. The relative contribution of each sector varies considerably for different pollutants, which has been discussed in detail in this report.

***Key Words*:**Urban Air Quality, Twin City Ahmedabad-Gandhinagar, Urban Air Pollution, Emission Inventory, SAFAR Ahmedabad

1. INTRODUCTION

Air pollution is a major concern worldwide for public health risk. In countries like India, it is one of the challenging tasks to maintain environmental health. Ahmedabad is one of India's largest and fastest-growing cities with a population of over 7.3 million. Generally, the level of air pollution in many cites was higher than the standards set by county and WHO. As per the CPCB report in 2010, the average concentrations of Particulate Matter (PM) in the ambient air of 180 cities were about six times higher than standards. **[1]** Continuous rise of population along with the lack of suitable measures for air pollution control means that there is a great potential that conditions may worsen in the future in Indian cities. As per studies conducted by various national and international organizations Ahmedabad city, ranked as one of the most polluted cities in the world. Air pollution increases in many cities like New Delhi, Beijing, and other Asian cities. The comprehensive analyses estimate that worldwide, ambient air pollution causes 4.1 million premature deaths each year mostly due to the effects of small particles on the progression of cardiovascular disease **[2].**

According to scientific studies in India, several cities and regions suffer from polluting emissions and resulting in poor air quality. Data collected by the Central Pollution Control Board (CPCB) in 2010 showed that 82% of 360 monitored sites across India exceed national air quality standards for particulate matter (PM). A 2012-13 study conducted by the Centre for Science and Environment (CSE) found that very few Indian cities (only two, Malapuram and Pathanamthitta in Kerala) had “low” air pollution concentration according to national standards **[3]**.

The different natural processes are going on such as volcano, forest fires, earthquake, decomposition of organic matter, dust storm, and salt sprays which release a considerable amount of pollutants into the air, however, during the past few decades. It has been noticed that the problem of air pollution has become more severe due to different anthropogenic activities including fossil fuel burning, biofuel burning, waste management, agricultural production, etc. which are responsible for the release of the vast amount of Green House Gases (CO_2, CH_4, NO_2, etc.) and air pollutants (PM_{10}, $PM_{2.5}$, CO, O_3, SO_x, etc.). Various studies conducted in India at various locations suggest that pollution levels vary significantly in different areas for its location, time, the period of sampling, and climatic conditions. Ahmedabad's inland location, dry & hot climate, can degenerate air pollution. A 2012 study evaluated air quality sources in Ahmedabad and five other Indian cities with a focus on PM_{10}**[4].** As per the study, the major sources for Particulate Matter (PM_{10}) in Ahmedabad were 30% road dust, 25% power plants, 20% vehicle exhaust, 15% industry, and 5% domestic cooking and heating, diesel generators, waste burning, and construction activities. Ahmedabad’s electricity grid is supplied by two thermal coal-fired power stations. The Torrent Power Plant 400 MW situated on the Sabarmati River. The second, larger 800 MW power station is in neighboring Gandhinagar. The Torrent Power Plant (formally known as Sabarmati Power plant) is one of the oldest power stations in County, operating since 1934; A 2013 study found higher concentrations of PM, SO_2, NO_X, and mercury surrounding the Ahmedabad and Gandhinagar due to Power Plant. **[5][6][7]**. Three Gujarat cities — Rajkot, Vadodara, and Surat — have all shown an increase in particulate pollution followed by Ahmadabad.

Rajkot and Vadodara ranked ninth in the country in terms of PM_{10} pollution. In Ahmedabad City, the levels of PM_{10} and $PM_{2.5}$ has a constant increase. The average PM_{10} level was 108 µg/m^3 in 2016 and 236 in 2018, with a 118.51% increase. $PM_{2.5}$ pollution 34 µg/m^3 in 2016 and 73 µg/m^3 in 2018, a 114.71% increase. According to the Air Pollution monitoring program, Torrent power plant emissions make up 39% of its particulate matter pollution and 22% road dust.

This paper reviews the air quality status of twin city Ahmadabad-Gandhinagar, Gujarat. This study highlighted the need for an updated and systematic citywide emissions inventory in Ahmedabad to inform improved air quality and future policy measures for emissions reductions.

2. STUDY AREA

The study region covers two cites Ahmedabad and Gandhinagar city (Figure-1). Twin city Ahmedabad-Gandhinagar is an important urban center in Gujrat and a rapidly growing metropolis in the country located near the Sabarmati river at an elevation of 55 m above mean sea level. The twin cities of Ahmedabad and Gandhinagar has a vast difference in lifestyle and culture. Gandhinagar is a new city with a peaceful, green, and spread population. Ahmedabad is a 14th-century heritage city with a fast and dense population. Today, the twin cities stand together as proud symbols of an era gone by and a future that holds many promises.

Figure-1 Google Image of Twin City Ahmedabad-Gandhinagar

The city Ahmedabad (City Area: 464.165 km^2) is the 7thlargest metropolis in Ahmadabad India. It is also a major industrial and financial city contributing 14% of the total investments in all stock exchanges in India and 60% of the total productivity of the state Gujarat, whereas, Gandhinagar (City Area: 177 km^2) is the capital of the State Gujarat and is the central point of the industrial corridor between Delhi and Mumbai. Being an important industrial hub it encompasses several air pollution sources such as thermal power plants, small scale, medium scale, and large-scale industries. Biomass burning (kerosene, wood, and cow dung) in slums for heating and cooking purpose is widely observed in the region. Open trash burning and brick kilns are some other pollution sources in the region.

Climatological features

Study area experiences semi-arid climate, with hot, rainy, and mild winter seasons. May is the hottest month in the region. Temperature varies between 28°C - 41°C during this season. The onset of monsoon takes place normally in mid-July and it lasts up to September. August is the wettest month of the year. The city received an annual rainfall of 732 mm between June to September. The winter sets in November and lasts till mid-February during which temperature varies between 12°C to 30°C.

Demography

As per the 2011 census report, most of the population of the region is concentrated in Ahmedabad (55,77,940) followed by Gandhinagar (2,02,776). The projected population for Ahmedabad for the year 2016-17 is 77,96,284 and Gandhinagar is 2,97,472. In 2016-17 there are around 9 slum pockets in the Gandhinagar area having a population of 13742, whereas there are around 800 slum pockets in Ahmedabad city having a population of 1178472. The increase in population has led to an increase in demand for food and other required resources and accelerates the rate of utilization of different services like industries, power plants, transportation, hoteling, etc. This rapid growth in the urban population considerably affects the emission rate of different pollutants, which has been estimated during the present study.

3. LITERATURE REVIEW

Chintan Y. Pathak, Hiren C. Mandalia D. Roy, and R. B. Jadeja (2014) studied the comparative analysis of ambient air quality of Ahmedabad and Gandhinagar in Gujarat. Both cities have been studied based on land use patterns and meteorological conditions.

Ahmedabad - Minimum concentration of particulates and gases pollutants were found during the summer season (April 2012 to June 2012). During the monsoon (June 2012 to August 2012), the minimum concentration of pollutants was found due to increased vertical dispersion, washout by monsoon rains, and suppressed wind erosion. All parameters had a maximum concentration in winter (November 2012 to February 2013). The minimum and maximum average concentration of SPM was recorded from 185 µg/m^3 to 362 µg/m^3. Maximum concentrations were recorded during January. A high concentration of Pollutants was observed in October due to the festival.

Gandhinagar - During monsoon, the average concentration was at the minimum levels. The factors responsible the same as Ahmedabad. The minimum particulates and gas concentration were found in the winter season due to minimum mixing height. The minimum and maximum average values of SPM were ranging from 178 µg/m^3 – 224 µg/m^3. The 86 µg/m^3 was the maximum average concentration of RSPM, which is below the permissible limit. However maximum concentrations were observed in January. During summer (April to June 2012), the concentration of gaseous & SPM pollutants was at the minimum due to high temperature, mixing height, high wind erosion, moderator stability, almost dry atmosphere, and less humidity. As compared with NAAQS, SO_2, and NOx concentrations were found to be very low from the prescribed limits. It found that the Annual average concentration levels of RSPM and SPM were slightly increased.

In 2010, the Government of India, through the Ministry of Environment, Forests and Climate Change (MOEF&CC), issued a memorandum that declared Ahmedabad and other key cities as critically polluted areas. The MOEF&CC directed industries to take necessary pollution control measures, adopt clean technology, reduce waste or face penalties. Taking a cue from the Central Government's orders, the Gujarat Pollution Control Board (GPCB) working with Ahmedabad Municipal Corporation to address air pollution **[8]**. The sources of emission are broadly categorized into two types: (A) Stationary emission sources and (B) Mobile source emissions. The stationary emission sources are further split into two major categories called (1) Large point source (LPS) or point source (2) Area source (A) Large point source or point source is identified as an individual facility basis or as a single source. Industrial units like cement, steel, bakery, chemical, metal industries, etc. are examples of point sources. Sources that are not identified individually are called area sources. This term is sometimes extended to cover groups of numerous small point sources that are too small, too numerous, and too dispersed to catalog individually. Area-sources also include the diverse, unpermitted small sources which individually do not emit a significant amount of pollutants but collectively contribute significantly to the emission inventory. Examples of area sources are slum cooking, street vendors, commercial cooking in hotels and restaurants, residential coal combustion and agricultural residue burning, etc. whereas non-commercial energy like bio-fuel (fuelwood, crop residue, and animal waste) and coal are widely used. Emissions from these sources are grouped into categories and calculated based on surrogate variables, such as a ward level population count in a region, which is used as an activity level. The quality of the estimates depends on how well this surrogate activity factor correlates with the emission rate for the source. (B) The mobile sources consist of on-road motor vehicles and off-road mobile sources. On-road motor vehicles consist of passenger cars, trucks, buses, motorcycles, etc. Emissions from on-road motor vehicles are a major portion of the emission inventory in megacities. Off-road mobile sources include trains, industrial generators sets, farm pumps, and construction equipment, etc.

4. MONITORING OF AIR POLLUTION

About more than twenty The ambient air quality monitoring (AAQM) stations are being operated and managed by several entities in the Ahmedabad city. The ambient air quality monitoring (AAQM) stations; fifteen by the Gujarat Pollution Control Board (GPCB), six by the Ahmedabad Municipal Corporation (AMC), one by Torrent Power. The GPCB'sAAQM stations in Ahmedabad measure SO_2, NOX, O_3, NH_3, CO, PM_{10}, $PM_{2.5}$, Pb, As, Ni, benzene, and Benzo-a-pyrene and report results from 7-10 days of monitoring. These monitoring stations record data twice a week, for at least 104 samples per year (as per CPCB guidelines). Three more AAQM stations are maintained in Gujarat Industrial Development Corridor (GIDC) areas for monitoring of VOCs only.

To protect public health and improve air quality the AMC is collaborating with IITM, Pune to develop a new AQI for the city. SAFAR's AQI operates in New Delhi, Pune Mumbai, and Ahmedabad since 2017. This AQI is an independent effort of the Ministry of Earth Science (MoES) and differs from the AQI implemented by the CPCB under the Ministry of Environment, Forests, and Climate Change **[9]**. IITM, Pune has installed eight new AAQM stations for the new SAFAR-AQI system in Ahmedabad in collaboration with the AMC.

CPCB installed online AAQM stations at Maninagar & Vatva, Ahmedabad and Sardar Bhawan, Sector 10, Gandhinagar

Air Pollution Sources

Several local sources contribute to Air pollution in Ahmadabad. Available literature indicates that rapid urbanization and industrialization have led to an increase in air pollution from vehicle-related emissions and stationary sources in Ahmedabad. From the past 10 years, the number of vehicles, including motorcycles and scooters, doubled in Ahmedabad, while the population grew by 58% **[10]**. The literature also depicts the annual growth rate of the motorized vehicles registered in the city to be five times higher than that of the city population. The fast-tracked urban development process is thus also increasing the emission of various toxic pollutants. The estimation of the amount of the emission load is important from a health point of view and hence it is necessary to account the same. Total Estimated Emissions by several sectors for the Ahmedabad city have been accounted for in tons/year for 2018.The details of sector-wise emission shown in Table 1.

Table 1: Total Estimated Emissions by Sector for 2018 (units – tons/year)

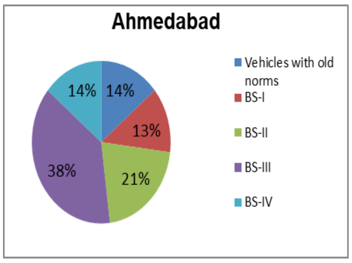
$PM_{2.5}$	PM_{10}	BC	OC	NOx	CO	VOC	SO_2
Transport emissions from road, rail, aviation, and shipping (for coastal cities)							
6,450	6,800	2,150	2,150	29,350	283,950	71,500	550
Residential emissions from cooking, heating, and lighting activities							
1,850	1,950	300	950	300	26,450	3,250	200
Industrial emissions from the small, medium, and heavy industries (including power generation)							
38,400	40,550	5,300	2,650	56,550	66,350	29,700	7,850
Dust emissions from road re-suspension and construction activities							
7,350	46,750	-	-	-	-	-	-
Open burning emissions							
2,150	2,250	150	1,300	50	10,350	2,100	50
Diesel generator set emissions							
2,500	2,650	1,500	450	23,650	6,300	600	250
Brick kiln emissions (not included in the industrial emissions)							
2,200	2,250	600	850	1,650	26,500	3,150	800
Total Emission of Ahmedabad City							
60,900	**103,200**	**10,000**	**8,350**	**111,550**	**419,900**	**110,300**	**9,700**
Source http://www.urbanemissions.info/india-apna/ahmedabad-india							

Ahmadabad and Gandhinagar have thermal coal-fired power plants having capacity such as 800 MW Gandhinagar plant and the 400 MW Sabarmati plant, one of the oldest in India. The Air Pollution contribution from almost 3,000 industrial units includes 855 chemical factories, 511 foundries, and 380 textile plants and others.**[11]** The low-efficiency brick kilns in Gandhinagar and trash burning in the surrounding area were also contribute to air pollution in the city. Further, the key sources of air pollution are discussed below-

Transportation

Direct vehicle exhaust is a predominant source of air pollution in Ahmedabad. Vehicles, especially two-wheelers and diesel-based trucks, account for over 20% of PM10 pollution in Ahmadabad **[12]**. Two-wheeler motor vehicles including mopeds, scooters, and motorcycles, all with a mix of two- and four-stroke engines have grown rapidly in Ahmedabad and make up the largest number of passenger kilometers traveled as well as the most rapidly growing fleet of vehicles. This study of different emission norms shows that in the year 2016 out of the total vehicles 13% vehicles meet Bharat Stage-I norms, 19%, and 21% vehicles meet Bharat Stage-II norms, 40%, and 38% vehicles meet Bharat Stage-III norm in Gandhinagar and Ahmedabad respectively **(Figure 2).**

A study carried out by Urban Emissions through the GIS-based model for PM_{10} emissions shows that motorcycles and automobiles as the primary vehicular emission sources in the city center; trucks remain mostly confined to the highways [13]. Further, while Ahmedabad, like other large cities in India, uses the National Fuel Policy's Bharat emission and fuel regulations, compliance is a challenge in the city **[14].**



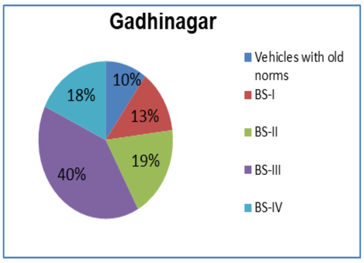


Figure 2: Percentage of vehicles meeting different emission norms for the study region

Road Dust

Road dust from automobiles, two-wheelers, trucks, and other vehicles is a major problem in Ahmedabad and other cities. Road dust accounts for over 25% of PM_{10} levels in Ahmedabad **[15].** Direct vehicle exhaust is the largest contributor to $PM_{2.5}$ and road dust is the largest contributor for PM_{10}, according to the 2012 Urban Emissions study **[16]**. Road dust resuspension can be reduced by road-carpeting using asphalt or tar, which is a major contributor to PM_{10} and $PM_{2.5}$ and cheaper and faster option than building concrete the roads. The main constrain of asphalt roadsis that the water penetration into the earth and easily damaged by extreme weather and rainy conditions. Melting asphalt also produces greenhouse gases, and VOCs and carbon monoxide (CO) are emitted during the paving process.

Thermal Power Plants

Ahmadabad's electricity grid is supplied by two thermal power stations, both coal-fired. The first, the Torrent Power Plant 400 MW power station situated in Ahmedabad City and the second, a larger 800 MW power station in Gandhinagar. The Torrent Power Plant (formally Sabarmati Power Plant) is one of the oldest power stations in India, operating since 1934. Based on available data, stack location, consumption, and production rates, the study found that power plants are a "major source" of emissions **[17]**. The emission level of PM_{10} and $PM_{2.5}$in power plants found high in the study of urban emissions dispersion models. Three additional studies found concentrations of SO_2, NOX, suspended particulate matter, and mercury surrounding the Gandhinagar plant [18]. Several studies on thermal power plants conducted by various national and international organizations in India show higher pollution levels, including particulate matter, SO_2, mercury, etc. The higher rates of health problems like chronic respiratory illness, asthma, cancer, premature death, etc. to communities living near thermal plants.**[19]**

5. EMISSIONINVENTORY

This emissions inventory conducted using google maps and available local activity and fuel consumption estimates for the selected areas. The road transport emission calculated through vehicle speed information to spatially and temporally allocate the estimated emissions to the respective grids. This data is summarized below for a quick look.

In the present study, Primary data has been collected for the transport sector, the residential sector, and the commercial sector. Primary data is obtained by collecting representative samples from study area information or data available for the slums, hotels, industries, thermal power plants, number of registered vehicles, etc., are collected from the secondary sources such as AMC, GMC,RTO,GPCB, earlier studies, and individual industry.

Emission inventories of gaseous pollutant CO, NOx, SO_2, and VOC as well as particulate matter $PM_{2.5}$, PM_{10}, BC, OC have been developed for the base year 2016-17. These inventories are developed by incorporating all major possible sources **[20].**

Gaseous Pollutants:

Emission inventory of CO

The relative contribution of different Sectors in total CO emission is shown in Figure 3

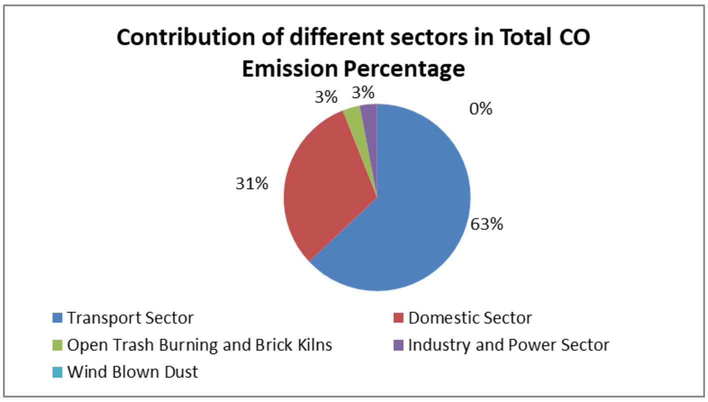


Figure 3: Relative contribution of CO emission from different sectors

The estimated total CO emission from all the sources is 150.46 Gg/yr. It has been found that the transport sector contributes maximum to the total CO emission, around 63%, followed by domestic sector (31%) which involved cooking and heating activity in slums, hotels, and restaurants, whereas industrial sector contributes 3% to the total emission followed by open trash burning and brick kilns. other residential complexes contribute 5% to the total emission of CO in the study area. The transport sector is the dominating source for

CO emission due to high population density driving to high vehicular density and major road network also. Transport is an important sector contributing to CO emission and estimated emission is found to be around 95.5 5 Gg/yr. Petrol, diesel, and CNG are the major fuel types used in the transport sector in the study area. Petrol driven vehicles emit more CO as compared to a diesel vehicle, the number of which found to be maximum in the study area. Another major source of CO is the Domestic sector, which includes emissions from slums where bio-fuel and chullahs are used for cooking. Low quality of cooking fuels with poor combustion technology drives to high CO emissions in these regions. The emission of CO from the domestic sector is around 46.20 Gg/yr. The emission from the residential sector is found to be well scattered over the region and the hot pots are observed over the areas having dense residential colonies and slum pockets.

Emission Inventory of NOx

The estimated total NOx emission from all sectors is found to be 102.94 Gg/yr. The relative contribution of different sectors in total NOx emission is shown in Figure-4 indicating 68% emission from the transport sector, 30% emission from industries and power sector, and 2% emission from the domestic sector. Transport is one of the most dominating sectors emitting around 69.54 Gg/yr NOx. In the transport sector, vehicular activity is the dominant source and it has been found that the CNG vehicles produce more NOx as compared to diesel and petrol-driven vehicles, but because of their small number, their contribution to total emission is found to be comparably less in the study area. The major hot spots identified over the study area are situated over the Ahmedabad Gandhinagar region having dense road network and also the industrial development. The trends of high emission are found over the GIDC area and central city area of Ahmedabad where most busy traffic junctions are observed. It is observed the spatial distribution of NOx emission from transport sector it has been found that the emission of NOx is higher along the National highways within the city boundary.

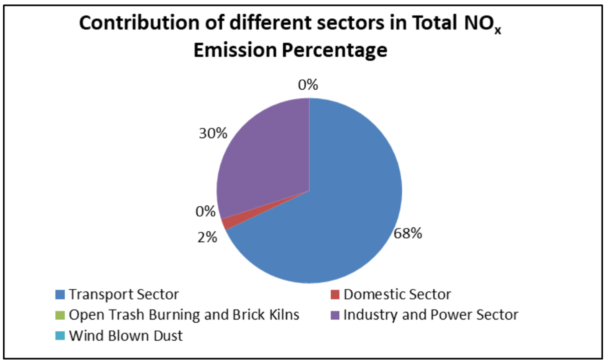


Figure 4: Relative contribution of NOx emission from different sectors

Emission Inventory of VOCs

The relative contribution of different sectors to total VOC emissions is depicted in Figure 5. The VOC emission from all sources is estimated to be around 65.97 Gg/yr where the transport sector plays a major role. Transport and industries are a major source of VOCs. 83% emission is from the transport sector followed by industries (14%), whereas the domestic sector and open trash burning and brick kilns contribute only 2% and 1% to the total emission.

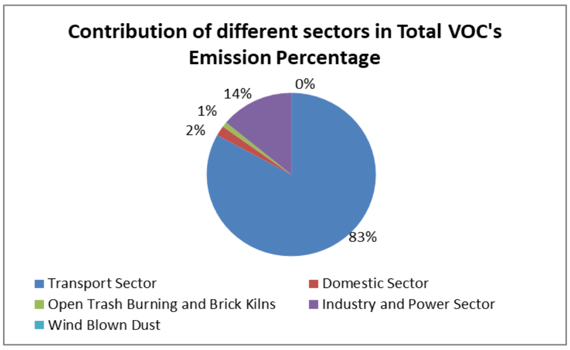


Figure 5: Relative contribution of VOC's emission from different sectors

Emission Inventory of SO_2

The contribution of each sector to the total SO_2 emission is given in Figure-6. A total of 62.52 Gg of SO_2 gets emitted from different sources in the study area per year in which emissions from the industrial sector dominates contributing 78% to the total emission. This is followed by the transport sector with a contribution of about 21%. Whereas SO2 emissions from the domestic sector and open trash burning are very less.

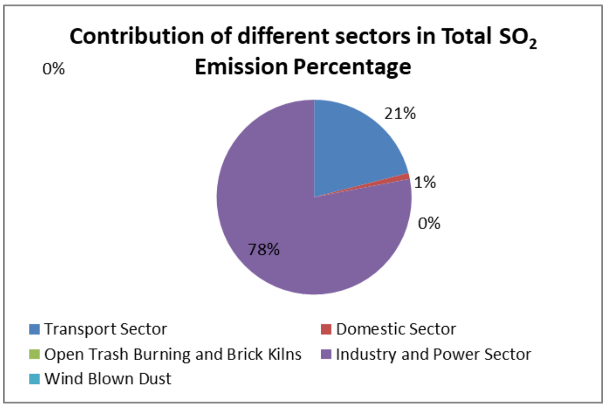


Figure 6: Relative contribution of SO2 emission from different sectors

Industrial coal and other fuel consumption play an important role in SO_2 emission. The main reason behind the high emission is attributed to a large amount of coal, diesel, kerosene, and other fuels consumption in industrial zones, having a considerably high amount of sulfur content. The SO_2 emission hotspots are found to be more confined over the industrial zones in the study area including GIDC areas.

Particulate Matters:

Emission Inventory of PM_{10}

The contribution of different sectors in total PM_{10} emission is shown in Figure- 7. Total PM_{10} emission over the study area is found to be 56Ggyear. It is observed that the major source of PM_{10} is windblown dust which contributes 52% to the total emissions. Industries are the second-largest source of

PM_{10}contributing 21% to the total emission followed by transport (17%), domestic sector (6%), and open trash burning and brick kilns (4%).

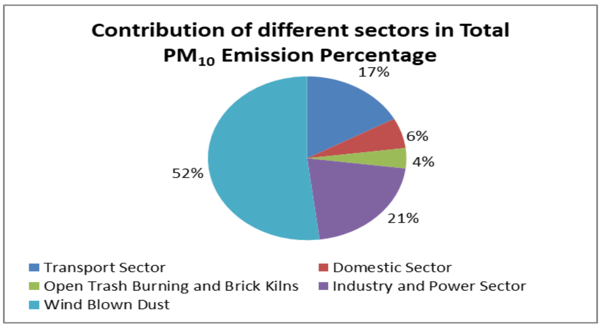


Figure 7: Relative contribution of PM10 emission from different sectors

Emission Inventory of $PM_{2.5}$

Figure 8 shows the relative contribution of different sectors to total $PM_{2.5}$ emissions. In contrast to PM_{10} major source of $PM_{2.5}$ is the transport sector contributing 36% of the total emission followed by industries that contribute 33% to the total emission. Windblown dust is the 3rdlargest source of $PM_{2.5}$ emission contributing 21% to the total emission followed by the domestic sector (7%) and open trash burning and brick kiln (3%).

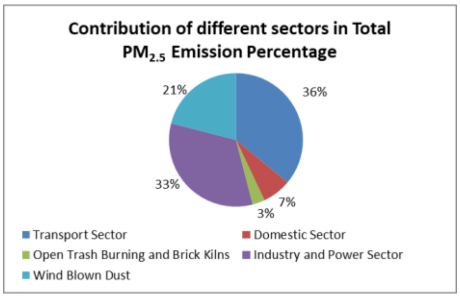


Figure 8: Relative contribution of $PM_{2.5}$ emission from different sectors

Emission Inventory of BC

Transport is the major source of BC in the AMC region contributing 53% to the total emission followed by industries that contribute 40% to the total emission. Domestic sector and open trash burning and brick kilns contribute 5% and 2% to the total emissions respectively. The relative contribution of each sector to the total BC emission is shown in Figure-9.

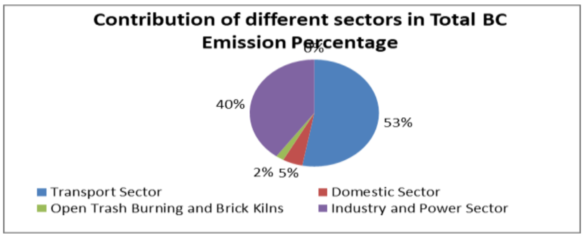


Figure 9: Relative contribution of BC emission from different sectors

Emission Inventory of OC

A total of 4.76 Gg/year OC gets emitted from different sectors in the study area. Out of 72% emission comes from the transport sector, 12% comes from the domestic sector, 10% comes from industries whereas open trash burning and brick kilns contribute 6% to the total emission. Figure-10 shows the relative contribution of each sector to the total OC emissions.

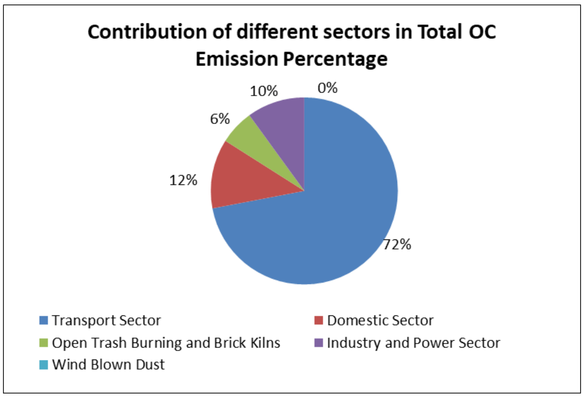


Figure -10: Relative contribution of OC emission from different sectors

Emission estimates done in the present work for the pollutants CO, NO_x, SO_2, VOC, $PM_{2.5}$, PM_{10}, BC, and OC over study area for the Area of Interest (30 km x 35 km) for the year 2016-17. The Emissions in Gg year of various air pollutants by different sectors for the Year 2016-17 in the area of approx. 35kmx30km covering Ahmadabad and Gandhinagar twin city area shows in Table 2.

Table 2: Sector-wise total Emission in the Ahmedabad-Gandhinagar Twin City (Gg/Year)

CO	NOx	PM_{10}	$PM_{2.5}$	BC	OC	VOC	SO_2
Transport Sector							
95.55	69.54	9.56	6.69	3.57	3.44	54.89	12.92
Industry & Power Sector							
4.31	31.00	11.90	6.20	2.72	0.44	9.42	48.90
Domestic Sector							
46.20	2.00	3.66	1.24	0.34	0.57	1.41	0.58
Windblown dust							
			29	4			
Open trash burning and brick kilns							
4.4	0.4	2.11	0.53	0.14	0.3	0.25	0.12
Total Emission							
150.46	**102.94**	**56.24**	**18.66**	**6.78**	**4.76**	**65.97**	**62.52**

6. CONCLUSION

The summary of estimated emission for the year 2016-17 in the review paper as been given in the above Table-2. The estimated total emission of $PM_{2.5}$ for the study area is calculated to be around 18.66 Gg/yr. The transport sector and industrial sector are playing a major role in $PM_{2.5}$ emission contributing around 36% and 33% respectively to the total emission, followed by windblown dust (21%). The domestic sector contributes 7% to the total emission in which emission from slum dominates where considerable use of kerosene, wood, and cow dung has been found. Open trash burning and brick kilns contribute 3% to the total emission. The relative contribution of each sector varies considerably for different pollutants which have been discussed in detail in this report. However, in conclusion, this maiden study conducted by The Ministry of Earth Sciences (MoES) and Indian Institute of Tropical Meteorology, Pune (IITM) in an undertaken project called System of Air Quality and Weather Forecasting And Research (SAFAR)-Ahmadabad reveals that the transport sector contributes maximum to the emission of $PM_{2.5}$, CO, NOx, BC, OC and VOC's. Maximum SO_2 emission comes from the industrial sector whereas windblown dust is the major source of PM_{10} emission

With the developments in dispersion models as well as detailed atmospheric chemistry, there is an increase in demand for accurate and consistent emission data of various pollutants for regional as well as global studies. However, most of the available inventories have a lot of uncertainty, especially for developing countries like India which further gets worse when extracted and crudely interpolated for use in finer resolution regional models targeted for city or region. The development of emission inventory related work is in an emerging stage in India. This can only be achieved if further high-resolution activity data of different sources are collected and made available. Hence there is a need to generate the primary data on a high resolution from various sources and collection of available secondary data to make a data repository at a single source point. This data should also involve the temporal/diurnal variation in emissions.

Another issue is related to the mismatch of finer resolution inventory developed for specific regions/cities for air quality now and forecasting often do not agree and integrate into the inventory developed for the global models with broader resolution. This is an important area that needs immediate attention and needs to be resolved. The current work also reveals several interesting features and hot spots that may not deteriorate the air quality for that particular spot due to dynamical meteorology but it will impact the other regions through long-range transport of pollutants. These statistics should be kept in mind while formulating and implementing air pollution mitigation strategies in the region. These results will go a long way in helping the air quality management system, environmental policymakers, and improving the accuracy of air quality forecasting.

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