

(RESEARCH ARTICLE)



Determination of air quality index and its impacts on human health in Chennai City

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Abstract

Air pollution in India particularly in metropolitan cities is a serious issue mainly due to vehicular emission, traffic congestion, burning of coal, fuelwood process. The objective of this project is to provide insightful details about the current situation of air quality across five locations in Chennai city and its impacts using an air quality detector meter. The concentration of pollutants namely Carbon dioxide (CO₂), Formaldehyde (HCHO), Suspended Particulate Matter (SPM), Total Volatile Organic Compounds (TVOC) and, meteorological conditions like Temperature and Humidity are measured at five polluted areas in Chennai metropolitan city and Air Quality Index values are calculated. From the above Air Quality Index values, it is found that Marina Beach bus stop, Velachery bus stop, Mount Road government estate metro station, Koyambedu bus station, Alandur metro station are identified as problematic zones and health impacts are Published.

Keywords: Air Pollution; Air Quality index; Particulate Matter; Health Impacts

1. Introduction

Air pollution occurs when harmful or excessive quantities of substances, including gases, particulates, and biological molecules are introduced into Earth's atmosphere. It may cause diseases, allergies and, also the death of humans; it may also cause harm to other living organisms such as animals and food crops and may damage the natural or built environment. Human activity and natural processes can both generate air pollution [4]. Atmospheric pollutants are substances that accumulate in the air to a degree that is harmful to live organisms or materials exposed to the air. Common air pollutants include smoke, smog, and gases such as carbon monoxide, nitrogen, and sulfur oxides, and hydrocarbon fumes [13, 14].

While gaseous pollutants are generally invisible, solid or liquid pollutants in smoke and smog are easily seen[1]. The six common air pollutants are also known as "Criteria Air Pollutants" enlisted by the US EPA are as follows,

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- Ground-level ozone
- Particulate matter
- Carbon monoxide
- Lead
- Sulfur dioxide
- Nitrogen dioxide

They are called criteria air pollutants because the US Environmental Protection Agency (EPA) regulates them by using two sets of criteria for pollutant standards [15, 16]. The first set of standards is designed to protect public health based on sound science [2]. This set of limits (known as primary standards) protects health. The second set of limits (known as secondary standards) aims to prevent environmental and property damage. When an urban area or other geographic area has concentrations of a criteria pollutant below the standard it is said to be “in attainment” and the area is declared to be an “attainment area.” Conversely, any area that has concentrations of a criteria pollutant above the standard is called a “nonattainment area [17, 18]”.

Pollutants can be classified as primary or secondary. Primary pollutants are substances that are directly emitted into the atmosphere from sources [3]. The main primary pollutants known to cause harm in high enough concentrations are the following:

Carbon compounds, such as CO, CO₂, CH₂, and VOC

Nitrogen compounds, such as NO, N₂O, and NH₃

Sulfur compounds, such as H₂S and SO₂

Halogen compounds, such as chlorides, fluorides, and bromides

Particulate Matter (PM or “aerosols”),

Either in solid or liquid form, which is usually categorized into these groups based on the aerodynamic diameter of the particles:

Particles are less than 10 microns which are also called “inhalable” since they can easily enter the nose and mouth. Particles less than 10 microns (PM₁₀, often labeled “fine” in Europe). These particles are also called “thoracic” since they can penetrate deep into the respiratory system. Particles are less than 4 microns [4]. These particles are often called “respirable” because they are small enough to pass completely through the respiratory system and enter the bloodstream. Particles less than 2.5 microns (PM_{2.5}), labeled “fine” in the US. Particles less than 0.1 micron (PM_{0.1}), “ultrafine” [5]. Secondary pollutants are not directly emitted from sources but instead form in the atmosphere from primary pollutants (also called “precursors”) [7]. The main secondary pollutants known to cause harm in high enough concentrations are the following: NO₂ and HNO₃ formed from NO and Ozone (O₃) formed from photochemical reactions of nitrogen oxides and VOC Sulfuric acid droplets formed from SO₂, and nitric acid droplets formed from NO₂ Sulfates and nitrate aerosols (e.g., ammonium bisulfate and ammonium nitrate) formed from reactions of sulfuric acid droplets and nitric acid droplets with NH₃, respectively Organic aerosols formed from the VOC in gas-to-particle Reactions [8].

2. Methodology

With worsening air quality, we must be aware of the quality of air that we breathe. Particulate matter (PM) has already emerged as one of the most criteria pollutants and has been made a global concern, especially in India [9]. Due to the rising rate of particulate matter in the atmosphere, large numbers of people were affected by various health effects and it also causes damage to the environment as well as materials [11]. According to a recent survey every year, 2.5 million people were dying in India due to air pollution. The majority of the deaths

are caused due to particulate matter which is suspended in the atmosphere and accounts for nearly 50% of the deaths in a year [12]. Therefore, it becomes a necessity to study the suspended particulate matter in the environment and its related health effects [10]. Here an attempt has been made to analyze and assess the concentration of suspended particulate matter and its related health effects in Chennai Corporation.

Objectives

Notify the public concerning the overall status of air quality through the amount line parameter which is easy to recognize.

Notify citizens about involving health impacts of air pollution acquaintance.

Rank places in Chennai Corporation for grade actions based on a measure of AQI.

Suggest health impact verge restrictions for the SPM parameter for which short-term air quality standards are set.

Emerging a uniform AQI considering objectives, health impacts, air quality standards, existing and future monitoring situations.

It defines the parameters, method and frequency of measurements, and other relevant aspects which are considered for the AQI monitoring.

Suggest a qualitative description of air quality and associated likely health impacts for different AQI values and evaluate proposed AQI with data from Chennai Corporation

The air quality index is a piece-wise linear function of the pollutant concentration [19]. At the boundary between AQI categories, there is a discontinuous jump of one AQI unit. To convert from concentration to AQI this equation is used [20]:

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

Where:

I = the (Air Quality) index,

C = the pollutant concentration,

C_{low} = the concentration breakpoint that is $\leq C$,

C_{high} = the concentration breakpoint that is $\geq C$,

I_{low} = the index breakpoint corresponding to C_{low} ,

I_{high} = the index breakpoint corresponding to C_{high} .

3. Device Used

3.1. Air Quality Meter

From above figure 1 we have always been curious about the air quality around our flat/locality, but till now had to depend on citywide data of AQI. Finally, here is a device that helps us in finding out the level of harmful elements in the air of any place that we want. It is portable, rechargeable, and can be used either outside or at home or office.



Figure 1 Air Quality Meter

3.2. Key Features

REAL-TIME MONITORING: PM2.5 PM10, CO2, HCHO, TVOC, Temperature, and Humidity

PORTABLE DEVICE: The monitor can be easily carried anywhere.

2.4 GHz WiFi + MOBILE APP ENABLED: Easy access of data on the web and AQI India mobile App

USB CHARGER: Charge the battery anytime with a Type-C USB cable

BATTERY CAPACITY: With a 1000 mAh lithium-ion battery, it can last up to 1 hr on a full charge.

4. Experimental Investigation of Air Pollution

4.1. Study Location

Chennai is also called Chennai or madras situated on the banks of the marina beach is the first largest city in Tamilnadu

The following are the locations in Chennai traffic:

4.1.1. Marina Beach Bus Stop

Marina beach bus stop is popularly known as the Marina beach bus stop. Marina beach is a natural urban beach in Chennai, Tamilnadu, India along the Bay of Bengal. The beach runs from near fort st. George in the north to foreshore estate in the south, a distance of 0.6 km (3 ml). Making it the longest natural urban beach in the country. It is located at 80.2824° longitude Tripliance and 13.0500° latitude Chennai, Tamilnadu.

4.1.2. Velacherry Bus Stop

Velacherry is a commercial and residential area in south Chennai and is the largest commercial center in south Chennai. It is surrounded by Guindy in the north, IIT Madras in the north-east, Taramani in the east, Perungudi in the south-east, Pallikaranai Wetland in the south, also Madipakkam in the south and south-west, Adambakkam in the west and north-west. It is located at E 80° 13.2725 E longitude and N 12° 58.5583 N latitude.

5. Mount Road Government Estate Metro Station

Anna Salai formerly known as St. Thomas Mount Road or simply Mount Road, is an arterial road in Chennai, India. It starts at the Cooum Creek, south of Fort St George, leading in a south-westerly direction towards St. Thomas Mount, and ends at the Kathipara Junction in Guindy. Beyond the Kathipara Junction, a branch road arises traversing westwards to Poonamallee to form the Mount-Poonamallee Road while the main branch continuing southwards to Chennai Airport, Tambaram, and beyond to form Grand Southern Trunk Road (GST Road or NH45). It is located at 80.265808°E longitude and 13.064369° N latitude.

5.1. Koyambedu Bus Station

Koyambedu is a neighborhood in Chennai, India. The Koyambedu area has become a major hub of activity in Chennai City after the inauguration of the Koyambedu market in 1996 and Chennai.

Mofussil Bus Terminus (CMBT) in 2002. The area is active round the clock owing to the movement of people and goods throughout the day. It is located at 80.197427°E longitude and 13.069362° N latitude.

5.2. Alandur Metro Station

Alandur is a zone of Chennai corporation, and an urban node in Chennai district in Guindy division in the state of Tamilnadu, India. It is Surrounded by Guindy in the North and East, Adambakkam in the South, Pazhavanthangal in the South-West, and St Thomas Mount in the North-West. As of 2011, Alandur had a population of 164,430. it is located at 80.204°E longitude and 13.003° N latitude.

As analyzed from the above-measured location Koyambedu and mount road government estate metro station have the highest percentage of PM 2.5 which is shown in figure 4 and figure 5. The other locations marina beach bus stop, Velachery bus stop, and Alandur metro station have moderate conditions which are shown in Figures 2, 3, 6. The graphical representation of AQI for measured location has shown in figure 7,8,9,10,11 which shows the range of the AQI for a different location

6. Calculation of AQI and Results

6.1. Calculation of AQI

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low}$$

6.2. Marina beach bus stop

$$PM_{2.5}$$

$$I = \frac{100 - 51}{35.4 - 12.1}(23 - 12.1) + 51 = 73$$

$$PM_{10}$$

$$I = \frac{100 - 51}{54 - 0}(34 - 0) + 51 = 82$$

6.3. Velacherry bus stop

$$PM_{2.5}$$

$$I = \frac{100 - 51}{55.4 - 35.5}(43 - 35.5) + 51 = 70$$

PM_{10}

$$I = \frac{100 - 51}{54 - 0} (44 - 0) + 51 = 91$$

6.4. Mount road government estate metro station

$PM_{2.5}$

$$I = \frac{200 - 51}{150.4 - 55.5} (89 - 55.5) + 151 = 170$$

PM_{10}

$$I = \frac{200 - 151}{154 - 55} (100 - 55) + 151 = 175$$

6.5. Koyambedu Bus Station

$PM_{2.5}$

$$I = \frac{150 - 101}{150.4 - 55.5} (63 - 55.5) + 101 = 105$$

PM_{10}

$$I = \frac{150 - 101}{154 - 55} (67 - 55) + 101 = 107$$

6.6. Alanthur metro station

$PM_{2.5}$

$$I = \frac{100 - 51}{55.4 - 35.5} (45 - 35.5) + 51 = 75$$

PM_{10}

$$I = \frac{100 - 51}{54 - 0} (51 - 0) + 51 = 97$$

7. Graphical Representation of SPM

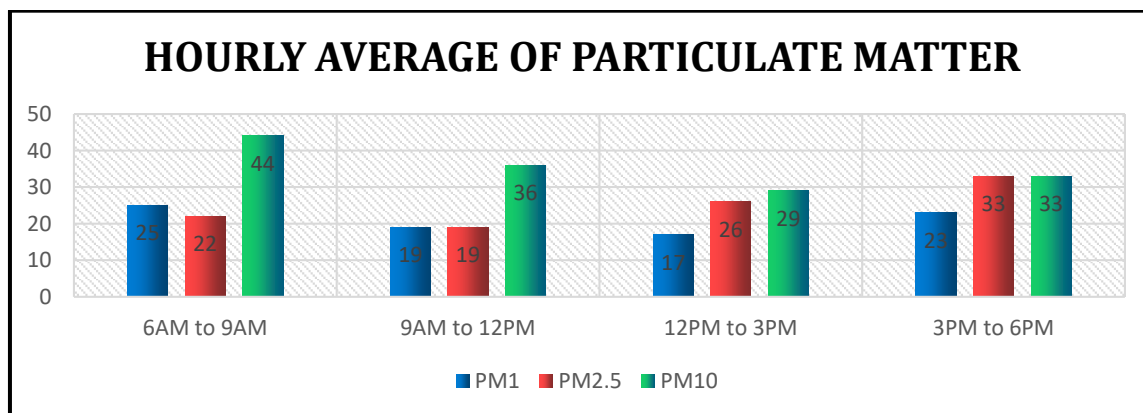


Figure 2 SPM Concentration observed in Marina beach bus stop

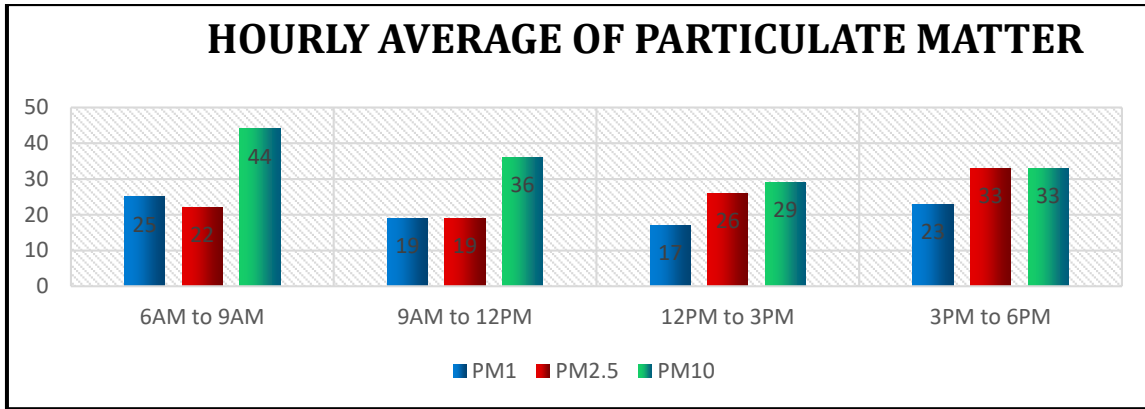


Figure 3 SPM Concentration Observed in Velacherry bus stop

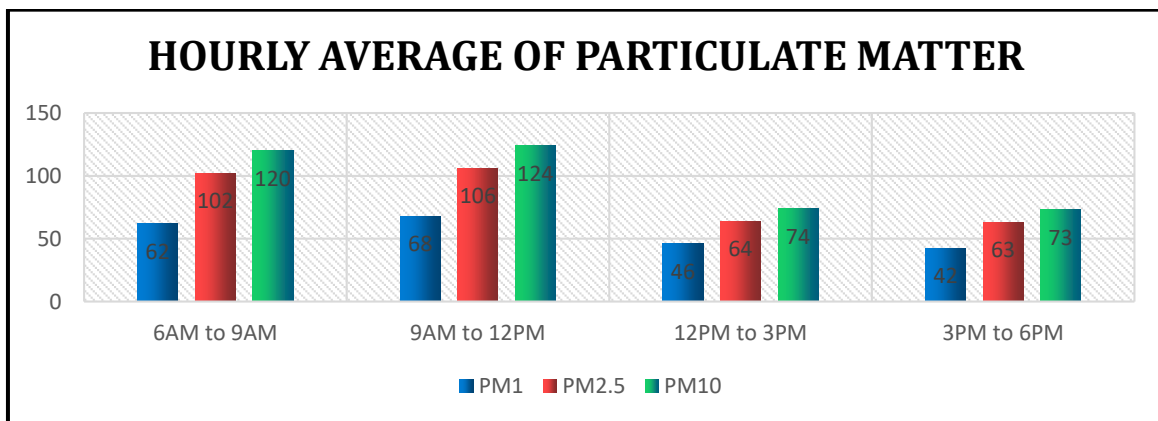


Figure 4 SPM Concentration Observed in Mount Road Government Estate Metro Station

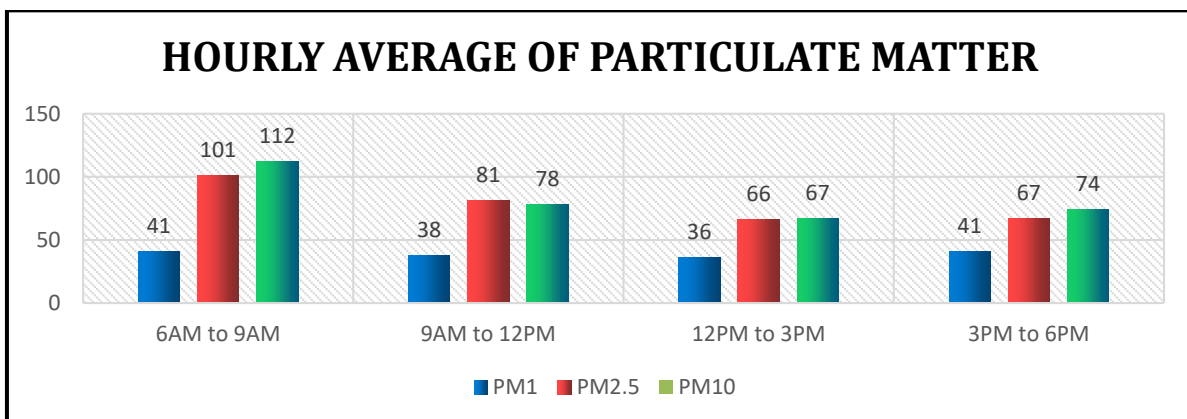


Figure 5 SPM Concentration Observed in Koyambedu Bus Station

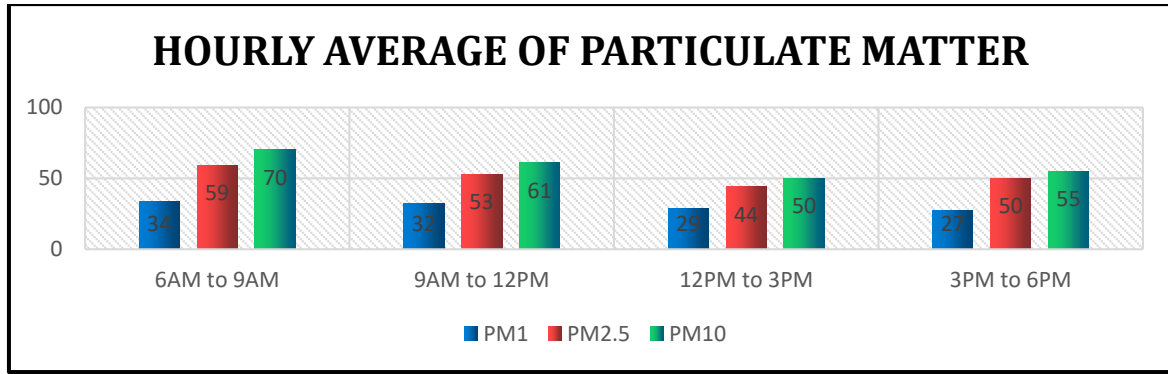


Figure 6 SPM Concentration Observed in Alandur Metro Station

8. Graphical representation of AQI

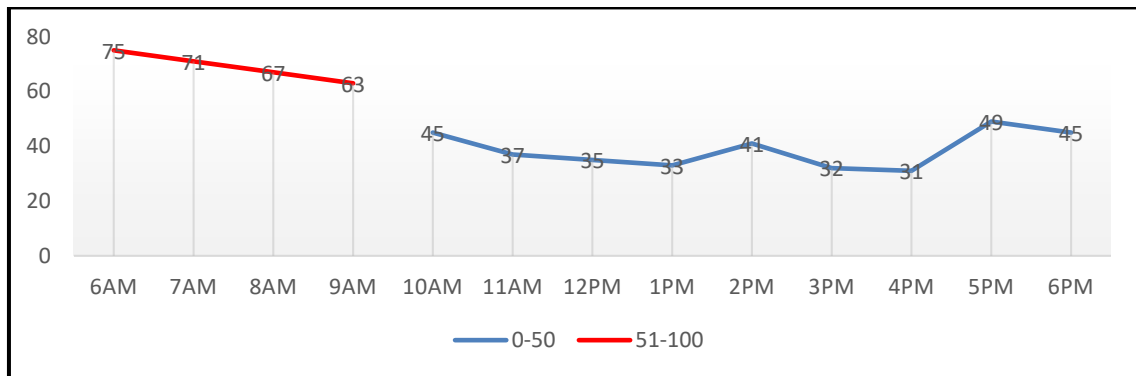


Figure 7 AQI Concentration Observed in Marina Beach Bus Stop

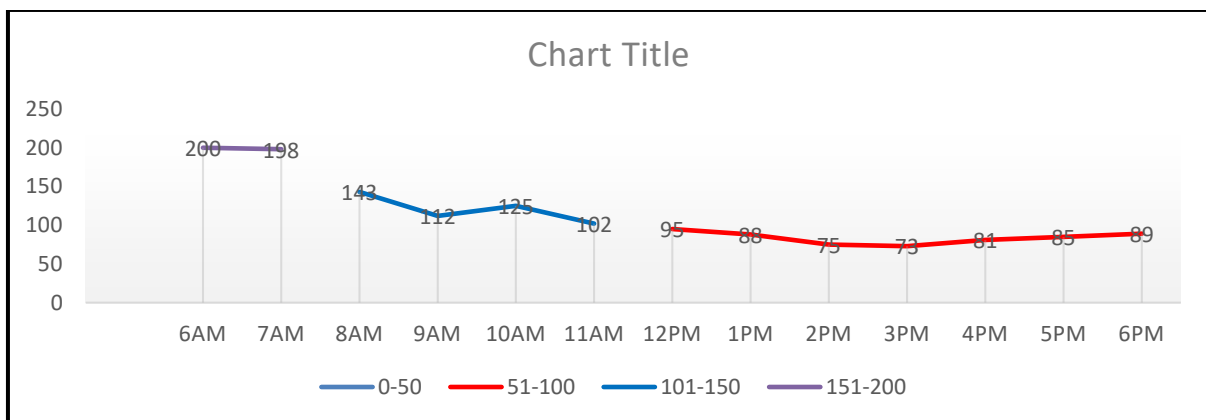


Figure 8 AQI Concentration Observed in Velachery Bus Stop

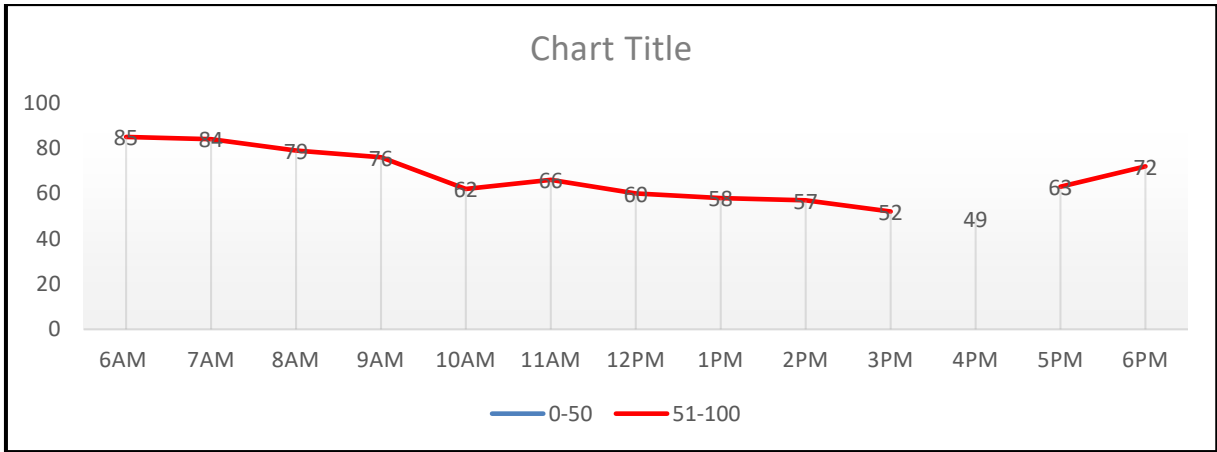


Figure 9 AQI Concentration Observed in Mount Road Government Estate Metro Station

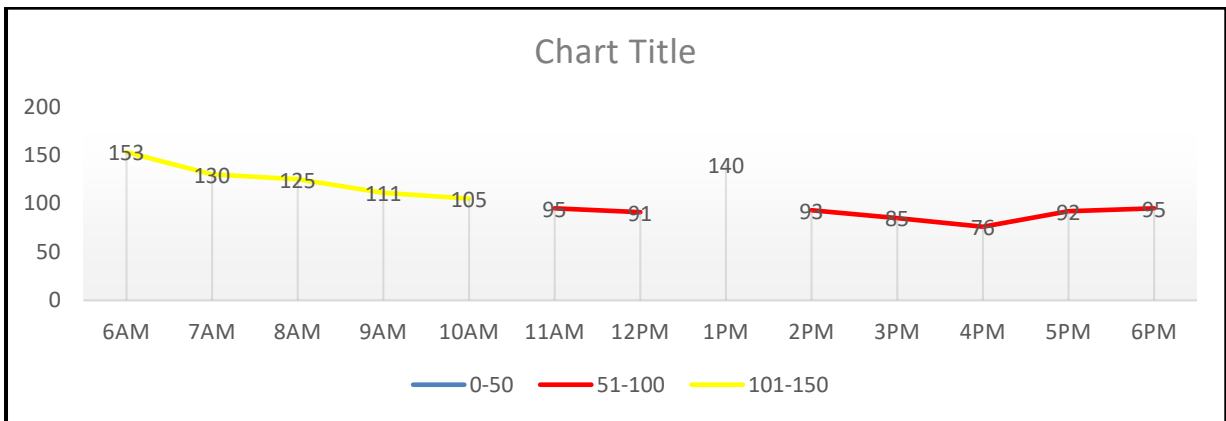


Figure 10 AQI Concentration Observed in Koyambedu bus station

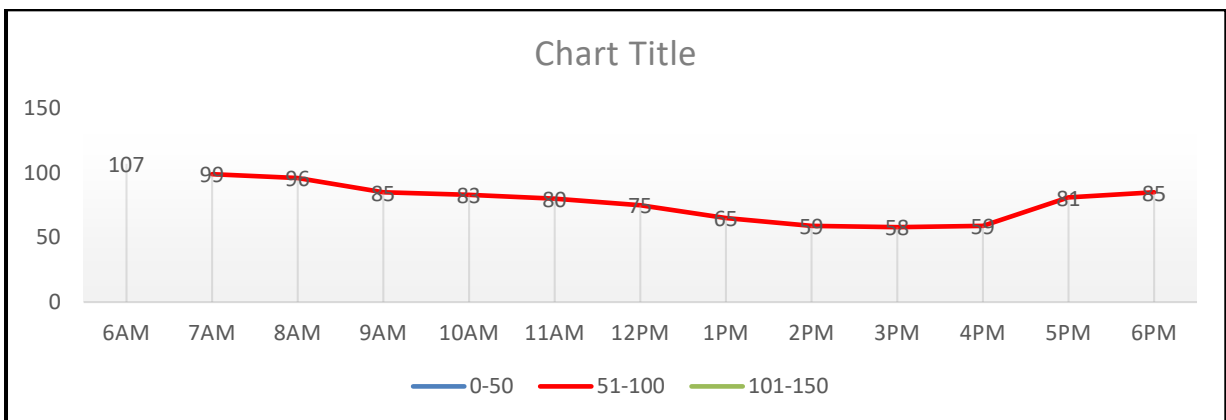


Figure 11 AQI Concentration Observed in Alandur Metro Station

9. Conclusion

During the time of the study, the major issues are considered, solved and interference is derived. These are categorized into two parts such as:

- The solutions obtained and
- Future scope

Solutions obtained

The short health effects of exposure combined SO₂, black smoke, and particulate include increased mortality rates and defects in pulmonary function. The bus rapid transit is also one of the major issues to be a concern as the model shift changes from car to motorcycle and it can also change the TVOC/NO_x ratio in the atmosphere. When the temperature rises the rate of photochemical reaction also rises.

In the town areas of Chennai, the wind speed is quite low and therefore the pollutants stay forever and accumulate in the atmosphere. The Wind direction is also highly related to PM₁₀ levels, downwind locations of precursor emission sources are strongly inclined to the high concentration of PM₁₀.

As analyzing from weekdays to weekends compared to weekdays, the weekend concentration is increasing rapidly. It concluded that PM_{2.5} pollution was slight during the non-heating period, but heavy in the heating season and that dusts from coal-fired boilers concentrated 10.9% to PM_{2.5}. AQI also rises when non-heating period from 6 A.M to 8 A.M

From vehicle emission the NO_x, SO_x is the major that affects the Inhalation of nitrogen dioxide (NO₂) can impair lung function, and increase susceptibility to infection, particularly in children. It can also aggravate asthma. NO₂ is not only a toxic gas but is also a precursor to several harmful secondary air pollutants such as ozone and particulate matter. It also plays a role in the formation of acid rain and photochemical smog.

The carbon dioxide (CO₂) also rises during heating and non-heating period. It is also a primary greenhouse gas; carbon dioxide absorbs and emits infrared radiation causing warming of the Earth's surface and lower atmosphere. Indoors, elevated levels of CO₂ can lead to drowsiness, headaches as well as a reduction in productivity.

Different types of methodologies were used to measure the concentration of particulates suspended in the atmosphere. It was observed that children who live with smokers are at higher risk of presenting a greater micronucleus induction.

From the time of the study, we observed that among five places Koyambedu and Mount Road Annasalai have poor AQI values while Alandur, Marina Beach Road, Velacherry has moderate AQI value. Therefore, it becomes necessary to reduce particle pollution in heavily polluted areas. It is mandatory to inform and create awareness to the public about the air quality that they are breathing and its related to health effects. The following are the air pollution control devices that are recommended to reduce the level of particle pollution in that particular area, Recycling air pollution by retrofit device and Fabric filter.

Future scope

There is a way to find or predict the future to address the problem or issue that is leftover or the scope of the current work. Because present study provides the range of SPM concentration and CO₂ analysis in heavy traffic areas. It also includes the breakpoints and their related health effects and in the environment.

Further forecasting can be carried out in all areas of the Chennai Corporation not only to measure the SPM concentration, but also NO_x, SO_x, ozone, carbon monoxide and lead with the help of this study. This study also describes the meteorological parameters that must be considered while measuring the pollution in the atmosphere.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be declared.

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