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Journal of Development Economics and Management Research Studies (JDMS) *A Peer Reviewed Open Access International Journal*
ISSN: 2582 5119 (Online)
Crossref Prefix No: 10.53422
09(12), 32-42, April-June, 2022
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Exploring the spatial and inter-temporal spill-over effects of Air Pollution in Chennai City- A Study

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Abstract

The impact of industrialization is manifold causing more employment, increased export, GDP growth but causing deterioration in the environment situation Air pollution, odourless air, smelly air which harms health, destroys plants and damages property. The effect of pollutants like SO_2 is primarily by industrialisation and increasing growth of population. CO_2 is also a key pollutant in the atmosphere and the sources of CO_2 are fossil fuel burning and deforestation. CO_2 is a good transmitter of sunlight but partially restricts infrared radiation going back from the earth into space. Particulates are tiny particles of solid or liquid matter present in the atmosphere and they are very helpful for the operations in the atmosphere like the formation of clouds and fog, absorbing gases in the atmosphere and creating reactions by being catalysts and the decomposition of ozone is possible only by dust, maintain the radiation balance and heat balance of the earth, and helps in the absorption capacity of the gases. The consequences of Air Pollution are severe on the environment, ecological impact, groundwater, soil, air**,** living organisms, acid rain, global warming, the greenhouse effect, climate changes etc. Ozone affects the upper layers of the skin, the tear ducts, lungs, biochemical, morphologic, functional, and immunological disorders (Lippmann, 1989). They are an important risk factor for lung cancer. Air pollution is also harmful to the environment and causes severe and permanent issues to a country. Considering the impact of Air Pollution, the Government of India has amended the AIR (Prevention and Control of Pollution) Act, 1981 vide G.O.Ms.3, DT.03.09.1983. This article is exploring the spatial and inter-temporal spill-over effects of Air Pollution in Chennai City.

Keywords: industrialisation, environmental issues, air pollution, cancer, health, ozone, radiation.

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Introduction

In the evolution of industrial development, it is observed an extraordinary dive at a rapid rate from primary industrialization to industrial modernization in our country. Its efficacy is manifold causing more employment, increased export, growth in GDP etc. However, the pressing contradictions of industrial modernization also impacted deterioration in the environmental situation of a country and the resulting deep-seated issues are a matter of serious concern. The increased use of natural resources brings not only causes depletion of such resources in the country but also severe environmental impacts. The emission from these industries, automobiles, fertilizer and pesticide use, plastic usage, wastes from the industries etc., have caused intricate health issues. Therefore, the need for harmony between environmental and development goals received attention to "ensure full consideration of the environmental soundness of development projects under review for possible assistance" (President Carter, 1977) and to provide special assistance and training to developing countries in the areas of environmental and natural resource management. In addition, the environmental issues have undergone qualitative changes in recent years mainly due to immense scientific development, especially after the Rio de Janerio summit (1992) which has focused world attention on the crucial environmental issue threatening human survival on earth. There are several areas in environmental issues but in this paper, an attempt is made to study the menace of 'air pollution in Chennai city.

Review of literature

The pollutants affect human health and cause diseases. And hence the Government take measures to control pollutant levels in ambient air. An air quality index is one of the important tools available for analysing the air quality and the Air Quality Index is used to assess the ambient air concentrations. Karl-Goran Maler (2001) discussed green accounting to determine the difficulties in creating an index with Kuznets curves by empirically estimating relations between environmental quality and GDP per capita. The finding is that among the pollutants a country with a very low income does not have much pollution but when the scale of the economy grows emissions of these pollutants will increase, but if the income per capita is high the economy will reach a turning point and pollution will decrease with further increases in per capita income. It is quoted that according to the World Bank, growth implies a win-win strategy where a country may in the long run obtain both increased material well-being and a better environment.

According to Stefan Ambec, Mark A. Cohen, Stewart Elgie, and Paul Lanoie (2013) articulated the implications for the design of environmental regulations and outlined directions for future research on the relationship between environmental regulation, innovation, and competitiveness. They have opined that twenty years ago Michael Porter has defied conventional perception about the impact of environmental regulation on business and well-designed regulation could enhance competitiveness. The traditional view of environmental regulation is that firms require to reduce an externality like pollution and restricted their options to reduce their profits. Over the years we find conflicting evidence concerning the Porter Hypothesis with alternative theories. A.K.Tachie, L. Xingle, L. Dauda, C.N. Mensah, F. Appiah-Twum, and I.A. Mensah (2020) estimated that trade openness, energy consumption, and urbanization escalated pollution emissions in the European Union. Foreign Direct Investment also impacted industrial SO2 emissions. The current capital-labour abundance ratio and the income level contributed to the

density of industrial SO2 emissions. David I. Stern (2018) the most representative and influential theoretical propositions are the environmental Kuznets curve and the Porter hypothesis, stating that economic growth and environmental quality follow an inverted N- or U-shaped pattern and there is nonlinear causality.

S.Chen, Y. Zhang, Y. Zhang, and Z. Liu (2019) have examined the impact of industrial restructuring on haze pollution and contended that an industrial structure dominated by heavy industry aggravated haze pollution. J. Jiao, X. Han, X, F. Li, Y.Bai (2017) have enplaned that technological improvements, investment in technology-driven intensive industries and consumption of the service industry have strongly driven SO2 emissions growth in the countries.

Sanchez and Stern (2016) investigated the potential drivers of both industrial and nonindustrial greenhouse gas emissions and found that the area of forest per capita and population density were key factors. Soumyendra Kishore Datta, and Tanushree De's (2021) study has found a strong relationship between energy consumption, pollution, and economic growth. They have examined the existence of the Environmental Kuznets curve corresponding to different panels of countries belonging to low, middle and high-income countries from 1990 to 2016. Hausmann test, fixed or random effect regression with robust standard error is carried out to test Environmental Kuznets curve concerning carbon dioxide, nitrous oxide, and methane. Kaya identity is used to analyse the contribution of growth of several component ratios toward overall pollution levels in different countries. They have used the Panel vector error correction model to find the unidirectional or bidirectional causality across GDP and emission of pollutants. M. Li, C. Li, and M. Zhang (2018) have discovered that industrialization and urbanization are the factors of a pollutant that causes emissions and identified per capita GDP, non-agricultural industries, and urban residents' per capita consumption as the greatest direct factors of pollutant emissions.

Causes and consequences of Air Pollution

The industrial revolution is the greatest contributor to air pollution and has emerged as a chronic problem in all the countries. Air pollution turns clear, odourless air, smelly air which harms health, destroys plants and damages property. It is out of gases and particulates into the atmosphere each year. The burning of gasoline for motor vehicles, burning of coal to heat buildings and helping manufacture products are some examples of causing pollution. Motor vehicles emit carbon monoxide (CO) is a major source of hydrocarbons (HC) and oxides of Nitrogen (NO_X) whereas fuel combustion in stationary sources is the dominant source of sulphur dioxide (SO_2).

Suspended particulate matter is the most prevalent form of air pollution. The concentration of sulphur-di-oxide (SO_2) is contributed primarily by industrialisation and the increasing growth of the population. Industries such as petroleum refineries, pulp and paper, chemical, iron and steel industries and non-metallic mineral industries contribute to this type of pollution to a greater extent. Thermal power plants are the major source of pollutants. CO_2 is also a key pollutant in the atmosphere and the sources of CO_2 are fossil fuel burning and deforestation. CO_2 is a good transmitter of sunlight but partially restricts infrared radiation going back from the earth into space. Emitted CO_2 in the atmosphere causes global warming of the earth's surface which account for a 57percent of the Global Warming trend. Yet another substance is SO_2 which is produced by the combustion of sulphur-containing fuels such as coal and fuel oils. Power plants and factories emit

90 per cent to 95 per cent of SO_2 and 57 per cent of NO_2 in the United States. Almost 60 per cent of the SO_2 emissions enable the emissions to travel long distances.

CFC is known as a greenhouse gas that contributes to global warming. It is produced by spray cans, discarded or leaking refrigeration and air conditioning equipment, and burning plastic and it stays in the atmosphere for 22 to 111 years. CFCs move up to the stratosphere gradually over several decades. Under high energy ultraviolet radiation, they break down and release chlorine atoms, which speed up the breakdown of O_3 into oxygen gas O_2. Photochemical air pollution is called 'smog' and it is a combination of the words 'Smoke' and 'Fog' which is a mixture of SO_2 and fog. The burning of coal and heavy oil that contains Sulphur impurities in power plants, industrial plants, etc., produces SO_2. This type of Smog is common during the winter season in cities.

Particulates are tiny particles of solid or liquid matter present in the atmosphere and they are very helpful for the operations in the atmosphere like the formation of clouds and fog, absorbing gases in the atmosphere and creating reactions by being catalysts and the decomposition of ozone is possible only by dust, maintain the radiation balance and heat balance of the earth, and helps in the absorption capacity of the gases. Oxygen absorbed on carbon particles might absorb sunlight more strongly and effectively than what free oxygen would do without carbon particles. Particulates help in chemical reactions in the atmosphere through oxidation, neutralization and other similar activities. It is stated that about 2000 million tonnes of particulate matter are released into the atmosphere by natural agencies like wind and dust storms and volcanic eruptions. However, man-made activities like the burning of coal, oil, gaseous fuels, wood, mining operations, forest fires and industrial emissions, etc., results in the release of about 450 million tonnes of particulates per year. In industrial and urban centres, it is estimated that there may be more than a lakhs of particulates per cubic centimetre. Polycyclic aromatic hydrocarbons (PAH) are important constituents of several organic particulates which are cancer-producing agents.

The main constituents of the atmosphere of the oxides of nitrogen are Nitrous oxide (N_2O), Nitric oxide (NO) and Nitrogen dioxide (NO_2). The concentration in the natural way of these gases would be N_2O- 0.25ppm, NO_2- 0.5 to 4ppm. Nowadays NO_x released through industrial activity and man-made sources might be more than 50 to 100 times than created by natural sources. The primary air pollutants found in most urban areas are carbon monoxide, NO_2, SO_2, Hydrocarbon and particulate matter these pollutants are dispersed throughout the world's atmosphere in concentrations high enough to gradually cause serious health problems.

The consequences of Air Pollution are severe on the environment, ecological impact, groundwater, soil, air**,** living organisms, acid rain, global warming, the greenhouse effect, climate changes etc. Ozone affects the upper layers of the skin, the tear ducts, lungs, biochemical, morphologic, functional, and immunological disorders (Lippmann, 1989). Carbon monoxide creates health issues like headache, dizziness, weakness, nausea, vomiting, and, finally, loss of consciousness, hypoxia, ischemia, and cardiovascular disease. Nitrogen oxide causes respiratory problems, inducing respiratory diseases, coughing, wheezing, dyspnea, bronchospasm, and even pulmonary oedema, reduce visibility and discolour fabrics and if the concentrations higher than 2.0 ppm affect T-lymphocytes, particularly the CD8+ cells and NK cells that produce our immune response (Chen T-M, et.al., 2007). SO_2 is 0.03 ppm affects human, animal, and plant life like

respiratory irritation, bronchitis, mucus production, and bronchospasm. Lead causes issues like inhalation, ingestion, and dermal absorption, accumulates in the blood, soft tissue, liver, lung, bones, cardiovascular, nervous, and reproductive systems, learning disabilities, impairment of memory, hyperactivity, and even mental retardation. PAH compounds are recognized as toxic, mutagenic, and carcinogenic substances. They are an important risk factor for lung cancer. Air pollution is also harmful to the environment and causes severe and permanent issues to a country.

Control of Air Pollution in Tamil Nadu

Considering the impact of Air Pollution, the Government of India has amended the AIR (Prevention and Control of Pollution) Act, 1981 vide G.O.Ms.3, DT.03.09.1983. The salient features are listed below:

Section 17	Empowers the Board to lay down emission, noise level and ambient air quality standards in consultation with Central Pollution Control Board.
Section 19	Entire State of Tamil Nadu has been declared as air pollution control area by the State Government.
Section 21	Requires the industries to obtain the consent from the Board to establish/ operate the unit in the air pollution control area.
Section 22	Prohibits the emission of pollutants in excess of the standards laid down by the Board.
Section 22 A	Empowers the Board to seek intervention of Court to restrain emissions exceeding the standards.
Section 23	Requires the industries to furnish information on the emissions in excess of the standards laid down by the Board, to the Board, the Collector of the District, the Revenue Divisional Officer, the Executive Authority of the Local body and the nearest Police Station.
Section 26	Empowers the collection of samples of air or emissions from any chimney, stack, flue or duct or any other outlet.
Section 31	Provides for appeal against the orders of the Board under Section21. Appeal has to be made to the Appellate Authority, within thirty days from the date of communication of the order.
Section 31 A	Empowers the Board to issue direction for closure, prohibition or regulation of any industry, operation or process or the stoppage or regulation of supply of electricity, water or any other service.
Section 37	Failure to comply with the provisions of section 21 (or) section 22 or directions issued under section 31A is punishable with imprisonment for a term which shall not be less than one year and six months, but which may extend to six years and with fine. Continued offence is punishable with an additional fine which may extend to five thousand rupees for every day during which such failure continues. If the offence continues beyond one year after the date of conviction, the offence is punishable with imprisonment which shall not be less than two years but which may extend to seven years and with fine.

Section 38	Offences like furnishing false information, non-furnishing information is punishable with imprisonment up to 3 months and a fine up to 10,000 rupees or both.

However, the Air Pollutions continue to remain unabated and the current situation of Chennai city is given below.

Table 1: Air Quality Index of T.Nagar

Month	2007	2008	2009	2010	2011	2012	2019	2020
January	94	105	105	154	154	123	115	76
February	119	129	207	109	119	125	95	74
March	101	141	132	170	103	164	80	40
April	100	98	98	125	137	111	78	26
May	91	124	194	154	210	246	86	45
June	57	149	111	178	113	190	119	46
July	91	182	170	133	92	92	102	51
August	88	96	160	160	182	96	74	42
September	90	113	182	167	287	176	67	68
October	97	121	160	177	279	176	61	71
November	135	144	164	83	255	271	93	65
December	143	162	204	129	253	107	93	71

Source: Tamil Nadu Pollution Control Board, computed from various years' data.

Table 2: Air Quality Index of Kilpauk

Month	2007	2008	2009	2010	2011	2012	2019	2020
January	164	156	156	95	44	92	98	61
February	99	139	121	94	115	271	151	55
March	117	149	113	190	135	541	113	43
April	100	95	95	98	162	301	110	26
May	91	123	143	76	113	301	119	42
June	129	79	119	78	127	162	75	33
July	52	87	94	87	176	170	102	62
August	147	200	119	97	137	168	82	34
September	154	135	99	93	125	160	76	40
October	200	165	149	63	86	170	70	49
November	182	128	119	79	170	115	62	52
December	129	79	119	78	127	162	88	60

Source: Tamil Nadu Pollution Control Board, computed from various years' data.

Table 3: Air Quality Index of Anna Nagar

Month	2007	2008	2009	2010	2011	2012	2019	2020
January	94	105	105	154	154	123	155	88
February	119	129	207	109	119	125	136	78
March	101	141	132	170	103	164	-	38
April	100	98	98	125	137	111	105	25
May	91	147	194	154	210	246	98	46
June	57	149	111	178	113	190	105	51
July	91	182	170	133	92	92	101	57
August	88	96	160	160	182	96	72	69
September	90	113	182	167	287	176	77	62
October	97	121	160	177	279	176	66	78
November	135	159	164	83	255	271	127	53
December	143	167	204	129	253	107	70	58

Source: Tamil Nadu Pollution Control Board, computed from various years' data.

Table 4: Air Quality Index of Adyar

Month	2007	2008	2009	2010	2011	2012	2019	2020
January	54	61	61	30	44	53	102	45
February	45	61	74	37	29	76	77	60
March	39	44	43	40	36	91	99	38
April	31	39	36	31	41	58	66	22
May	36	49	51	43	59	77	71	39
June	31	41	25	36	34	78	53	45
July	40	27	19	29	44	65	30	46
August	31	24	39	33	55	57	51	57
September	32	44	33	27	55	71	41	41
October	53	67	50	28	86	71	46	59
November	43	53	60	34	75	83	52	48
December	63	61	65	45	92	72	47	52

Source: Tamil Nadu Pollution Control Board, computed from various years' data.

The air quality will be good if the index is 0 to 100, moderate if it is 101-200, poor if it is 201-300 and very poor if it is 301-400. The data are given in Table 1, Table 2, Table 3 and Table 4 indicate that Adyar has good AQI when compared to Anna Nagar, T.Nagar, and Kilpauk.

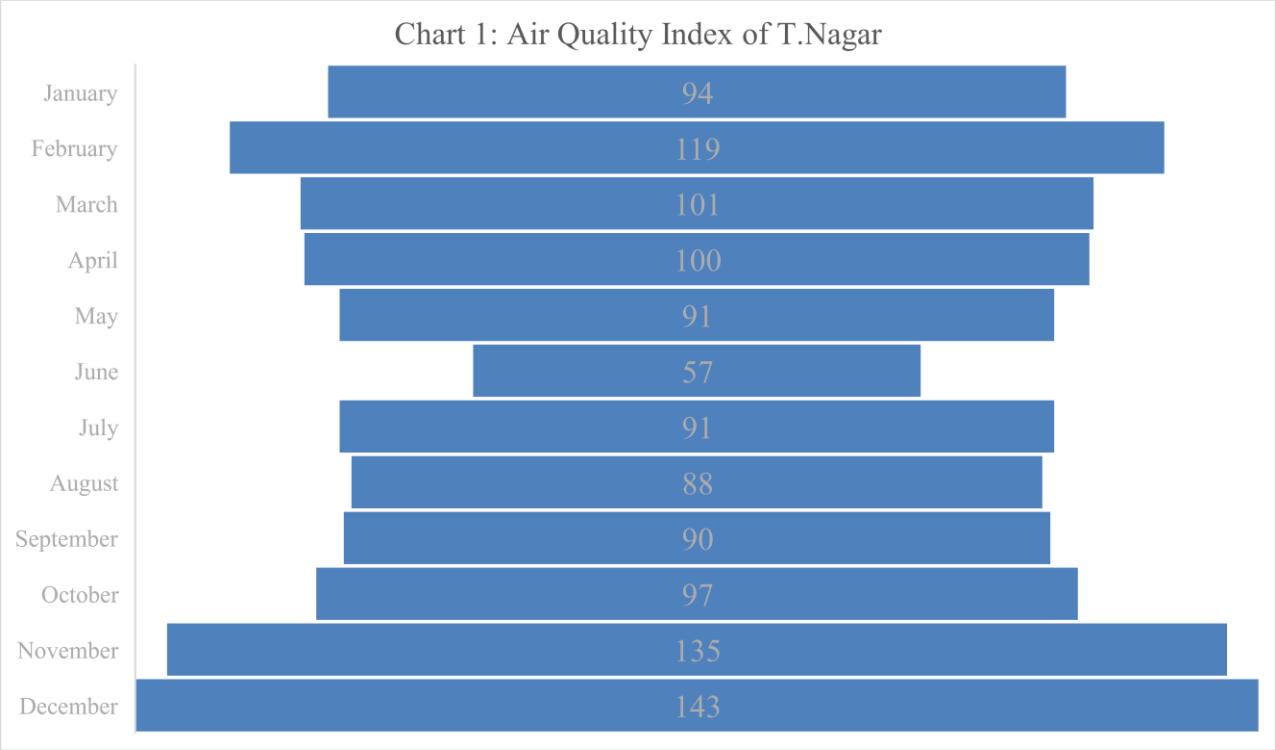
Chart 1: Air Quality Index of T.Nagar
January
94
February
119
March
101
April
100
May
91
June
57
July
91
August
88
September
90
October
97
November
135
December
143

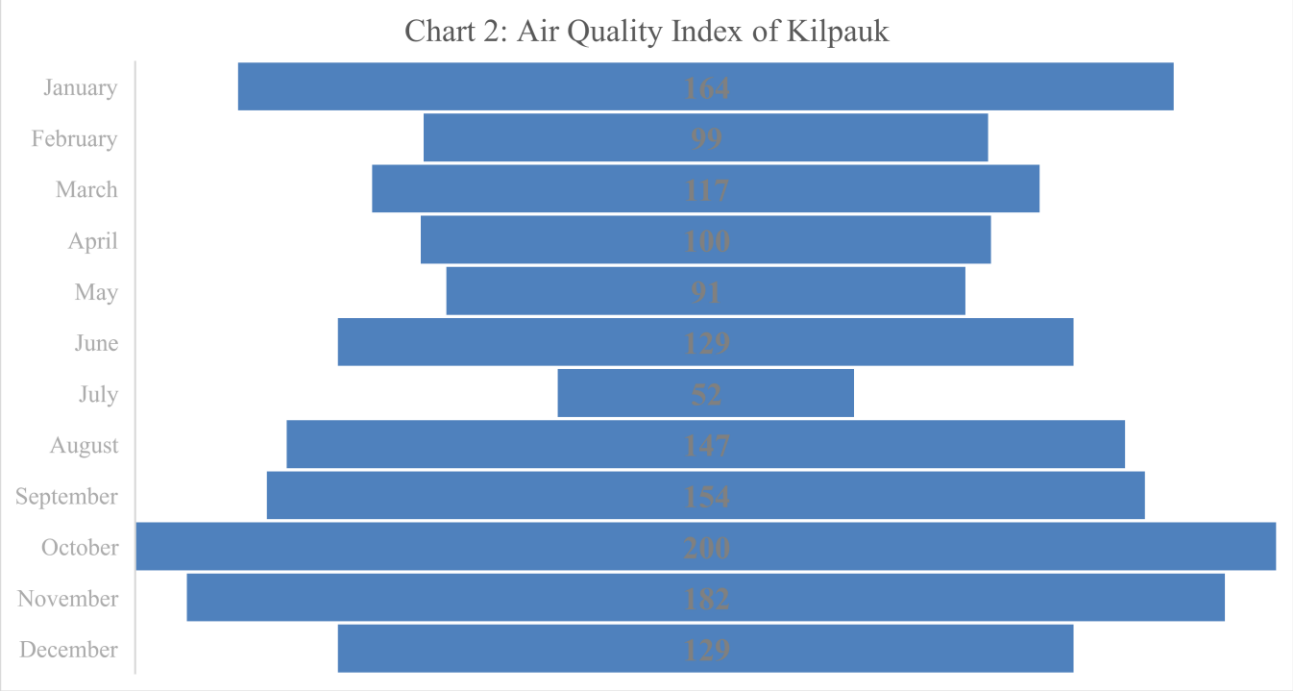
Chart 2: Air Quality Index of Kilpauk
January
164
February
99
March
117
April
100
May
91
June
129
July
52
August
147
September
154
October
200
November
182
December
129

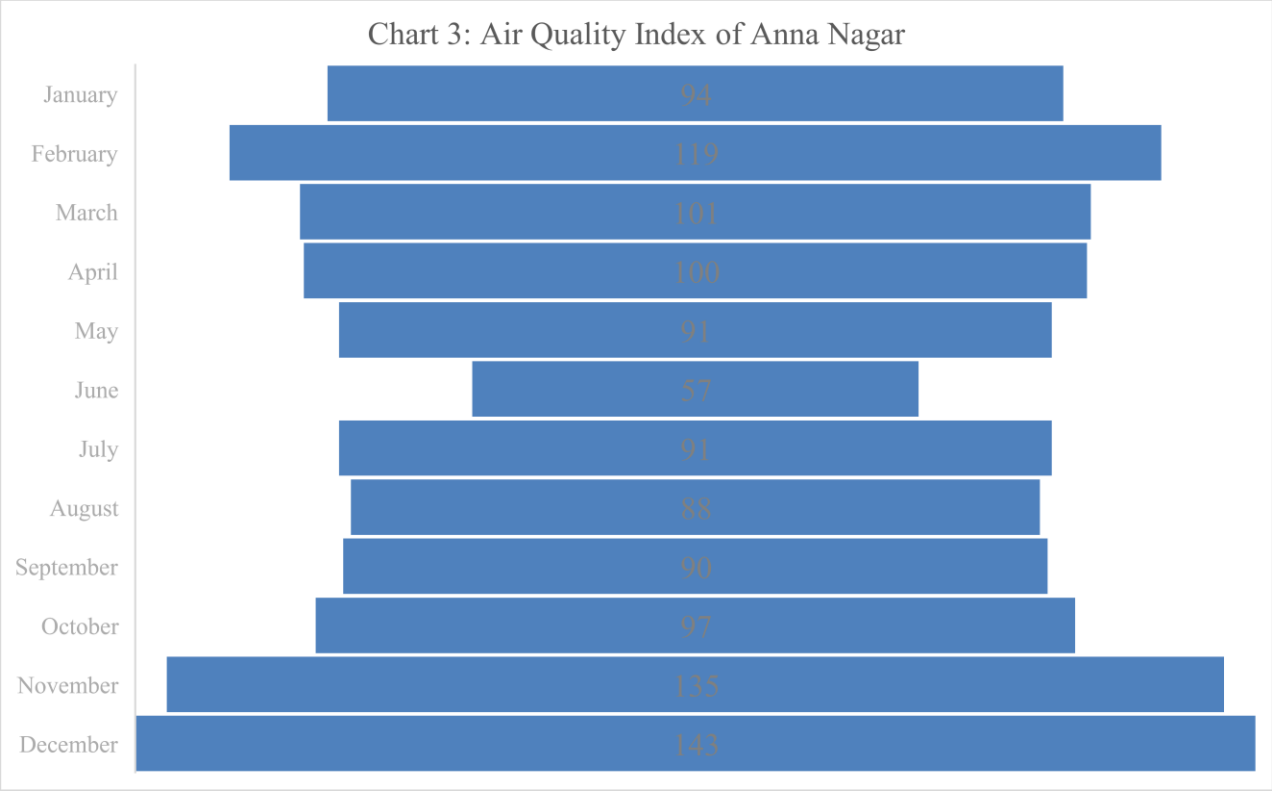
Chart 3: Air Quality Index of Anna Nagar
January
94
February
119
March
101
April
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June
57
July
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August
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September
90
October
97
November
135
December
143

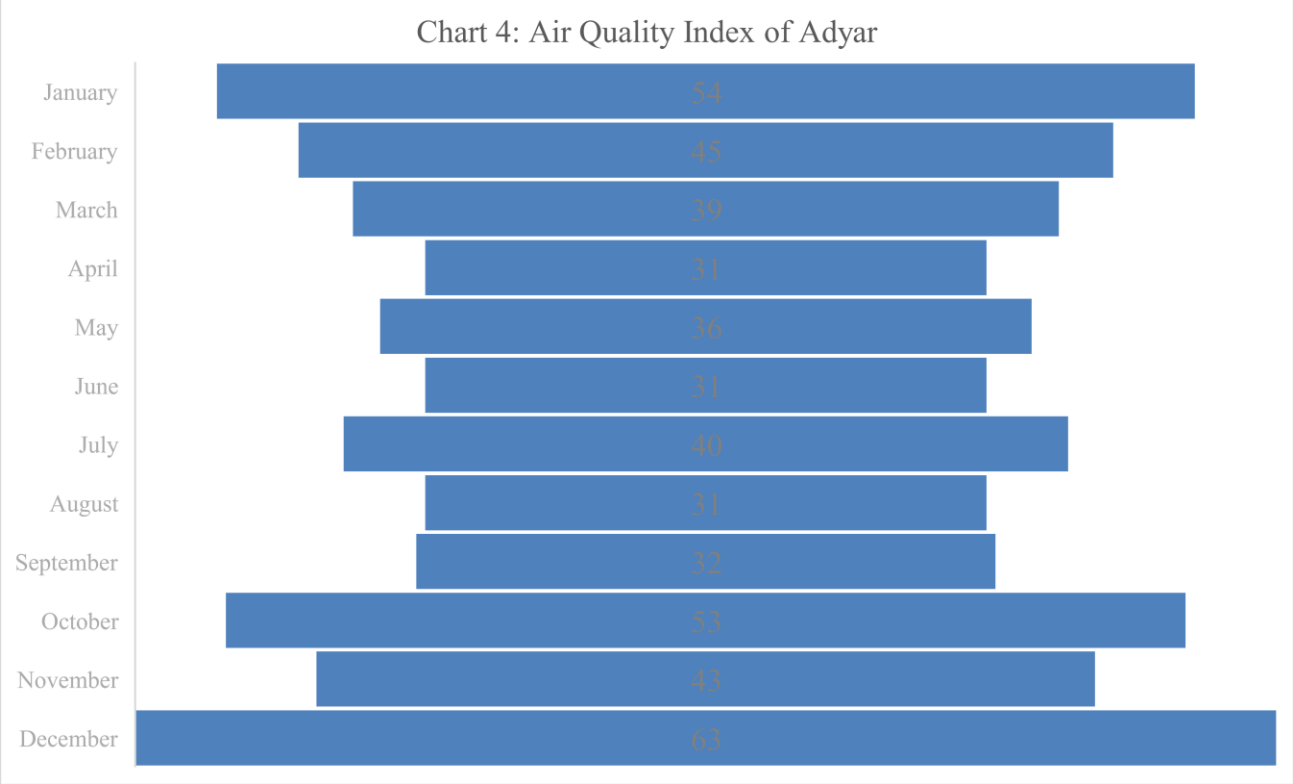
Chart 4: Air Quality Index of Adyar
January
54
February
45
March
39
April
31
May
36
June
31
July
40
August
31
September
32
October
53
November
43
December
63

Chart 1, Char 2, Chart 3 and Chart 4 provides the AQI from January to December for the years given in the Tables for T.Nagar, Kilpauk, Anna Nagar, and Adyar. Uniformly in all the four areas of Chennai city, AQI is high during December, October, January and February months. In October, due to Deepavali and during January it is Bogi Pongal festival time the AQI is high despite the controlling measures taken by the Government as per the Court's direction.

Conclusion

Air pollution continues to impact significantly the environmental as well as public health issues in Chennai and other places. It causes 1.8 million premature deaths and 49 million disability-adjusted life-years lost, and it is a top risk factor for ill-health in our country. Therefore, measures have been taken by the government to improve ambient air quality like the use of CNG, closure of high polluting industrial units, phasing out older vehicles beyond the permissible years as per the Act, vehicle pollution certificates and encouragement to people to use public transport. In addition, the increased media attention over the last two years led to several policy initiatives taken by the judiciary or the legislative. Many directives have been issued by the Supreme Court of India and the National Green Tribunal.

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