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Assessment of air quality index of urban area and epidemiological investigations in Chennai

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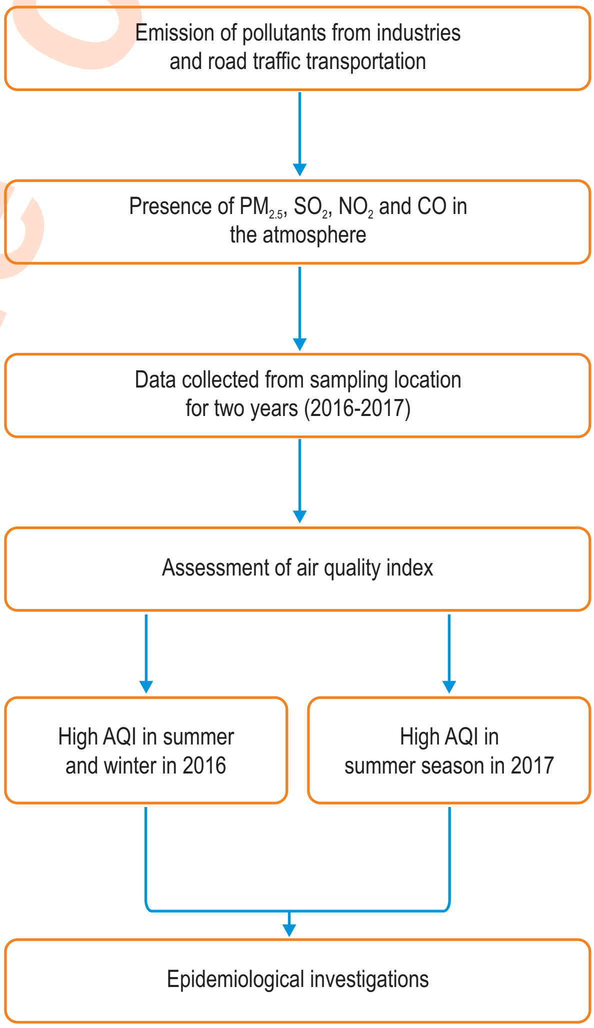
Abstract

Aim: To study air quality of Chennai city by comparing the air quality index (AQI) with the National Ambient Air Quality Standard (NAAQS) values.

Methodology : In urban area, a major straddling problem is air pollution. Analyses was conducted during Jan 2016–Dec 2017 for $PM_{2.5}$, SO_2, NO_2 and CO at different seasons in Manali, Chennai. Fine particulate sampler and Lutron CO meter were used to estimate $PM_{2.5}$ and CO levels.

Results: Due to different climate changes in India, higher concentration of pollution occurred during summer and monsoon season. The commercial and residential area experienced lower pollution compared with industrial areas. Case-control study showed that the result of odds ratio was significant.

Interpretation: Commercial and traffic may have significant influence on air quality in Chennai.



Key words: Air Quality Index, Air Pollutants, Epidemiological investigation, Industrial area.

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Introduction

Polluted environmental condition directly affects human beings and other living organisms. Pollution free and clean environmental means absence of unwanted or foreign materials (Nikolina and Krassimira, 2014; Ministry of Environment and Forest, 1986). Air pollution is one of the dominating issues in the recent era (Dwivedi and Shashi, 2012; Lamzira Lagidze *et al.*, 2015). In urban areas like Chennai, the industrial indoor air pollutants are another source of air pollution (Dalal *et al.*, 2013). During festivals, bursting of firecrackers the pollutants into the atmosphere (Samavia Batool *et al.,* 2016 and Wu N *et al.*, 2015). There is another one source called transport source which emits severe concentration of NO_X, SO_2 to the environment (Handan Ucun Özel, 2014; Oktay *et al.*, 2018). The burning of fuels releases these kinds of exhaust into the environment (Kiran *et al.*, 2015; Mahla *et al.*, 2017). Some typical industrial wood painting plants produce high volatile organic carbon (Sinha and Shivgotra, 2012; Kamakshi *et al.*, 2019). In feeding of earthworm casts also leads to emission of air pollutants like NH_3, H_2S (Jae-Sung Yoon and Byung-Sung, 2016; Jae-Suk Choi *et al.*, 2014). In Chennai, level of air quality decreases rapidly due to industrial developmental activities and daily use of automobile vehicles abundantly (Ding Weina *et al.,* 2015; Ravi *et al.*, 2016).

Emission of unburned hydrocarbons (UBHC) and NO_X is higher while burning charcoal briquettes (Mandal *et al.*, 2013). Pollutants like SO_2 can easily dissolve in water. Leading to acid rain which affects the development of plants (Zomuanpuii *et al.*, 2014; Ponmurugan *et al.*, 2015). Previous studies show the various types of air pollution such as from SO_2 , NO_2, HC, COx and suspended particulate matter for different weather conditions (Wang *et al*., 2017). Due to the emission of particles like SPM, NO_2, SO_2 and COx, it is known that illness and health afflictions are caused. (Skromulis and Noviks, 2011). Vulnerable changes in indoor and outdoor climatic conditions often lead to health issues in children (Danesh *et al.*, 2013). Since children are more sensitive to such affliction, they enter lungs and respiratory pathology. (Goswami *et al*., 2013). For adults, these air pollutants cause oxidative stress that leads to mental disorder (Durga *et al*., 2015; Butchiram *et al*., 2012).

Availability of contaminant biomass fossil fuels in villages lead to emission of hazardous pollutants in the atmosphere. It contributive to lung function abnormalities in women (Vipin *et al.*, 2013). These excess biomass emission in fossil fuels can be removed by physical, chemical and biological method (Ojha *et al.*, 2015). Dissolving pollutant in any coal mining industry into river affects fish population. (Mylliemngap and Ramanujam, 2011). To avoid these kinds of maladies, proper control measures and monitoring techniques should be followed in the industries as well as in vehicle emissions (Bucher, 2016; Raina Pal *et al*., 2014). If ASTM D6751 specification is complied, there would be a substantial reduction of HC and CO from emission form a vehicle's engine (Mahla *et al.*, 2017). By promoting green technology, which has played a dominant role in environmental protection, the CO emission in a particular location gets reduced (Ding *et al.*, 2015). Assessment of air quality index in various locations help to find out variation of polluting agents in these specific places. In a global scenario, releasing of air pollution matter shall be reduced by proper control measure (Radhapriya *et al.*, 2012). Particulate matter refers to mixture of micro solids and micro liquid components such as nitrates, sodium salts and carbon mixing with air (Mondal *et al*., 2013). NO_2, SO_2 and SPM are the major air pollutants and they cause their adverse effects on human living in India (Air Quality Expert Group, 2012).

Biomonitoring of plants is used as a tool to analyse the impact of air pollution on plants (Karaer *et al.*, 2011). The above mentioned pollutants are emitted directly from the burning of fossil fuels in industrial operation and automobile vehicles (Mohapatra and Goswami, 2012). The particulate matter particles released from metallurgical industry is also one of the root cause of air pollution (Madan and Verma, 2014). Automobile vehicle is the major source of air pollution in the urban area (Sinha and Shivgotra, 2012). It contributes 60-70% of total pollutants to environmental condition (Pollution, 2011). Air quality index score is used to assess and analyze the level of air quality in the environmental (Chaudhuri and Chowdhury, 2018). The concentration level of pollutants such as SO_2, NO_X, HC, CO and suspended particulate matter may vary due to change in environmental condition (Thambavani and Maheswari, 2013).

In the present study, an attempt was made to assess and evaluate air pollution of 2 years from of January 2016 to December 2017 during summer, winter and monsoon season in Chennai.

Materials and Methods

Study area: Chennai is one of the biggest industrial hubs in South India. Whereapproxmatly 3,500 small, medium and largescale industries operate. For this study, Manali (13° 09' 29.7" N; 80° 15' 38.8" E) located in Chennai was selected for the analysis of air quality index (AQI) in various seasons. Major source of pollution in Manali are Chennai Petroleum Corporation Limited (CPCL), Ennore thermal power station, small, medium and large scale industries and heavy vehicles traffics.

The following formula was used to calculate the air quality index in a particular location (Saravanakumar *et al.*, 2016).

$$AQI = ¼((IPM_{2.5} /SPM_{2.5}) + (ICO/SCO) + (ISO_2 /SSO_2) + (INO_2 /SNO_2)) \times 100$$

In this study, nearly 731 samples of PM2.5 , CO, SO_2 , NOx were collected from Manali. It has been noted once in two days during the years 2016 and 2017. The average values of these samples were calculated for the four seasons of Chennai, India such as winter, summer, pre-monsoon and rainy-monsoon seasons.

Estimation of particulate matter: The respirable particulate matter (SPM) of 2.5μ ($PM_{2.5}$) was measured with the help of fine particulate sampler APM 550 MINI with Teflon filter media attached for a period of one in two days. By measuring the weight of filter media before and after sampling, the concentration of $PM_{2.5}$ was calculated in terms of $\mu g\ m^{-3}$.

Ambient CO concentration in the atmosphere was estimated by Lutron CO meter GCO-2008. CO meter is one-chip of microprocessor large scale integration circuit. The measurement was taken in an open environment by monitoring the change in reading with CO meter.

Modified West Gaeke method was followed to estimate SO_2 in Manali. SO_2 was measured by absorbing the SO_2 particles from the atmosphere into a sodium tetrachloromercurate solution to make the mixture of stable dichlorosulphitomercurate. For photometrical estimation, formaldehyde was mixed with stable mixture (Saravanakumar *et al.*, 2016). NO_2 concentration in air was estimated by Jacob Hochheiser method. NO_2 from the atmosphere was absorbed by sodium hydroxide solution to make a stable mixture called sodium nitrite. The photometrical estimation was used to calculate nitration produced in the mixture.

Epidemiological Investigation: By conducting a case-control study in terms of odds ratio, the effect of air pollution exposure and allergic symptoms in people of Manali. Cases and controls were determined based on defined criteria and symptoms. People with allergic symptoms (eye and nose, only eye or nose). Eligibility criteria included the people residing in Manali, Chennai for past five years presenting symptoms for the recent period (incident cases), avoiding the people those who are ailing long period of symptoms (prevalent cases).

Results and Discussion

Air quality index describes the overall atmospheric condition of the environment. Table 2 shows permissible health concern based upon AQI values. The following formula was used to calculate the air quality index in a particular location (Saravanakumar *et al.*, 2016).

$$\textbf{AQI} = \tfrac{1}{4}(IPM_{25}/SPM_{2.5}+ICO/SCO+ISO_2/(SSO_2+INO_2/SNO_2)\times 100$$

In this study, the concentration level of air pollutants such as $PM_{2.5}$, CO, SO_2 and NO_2 in Manali location was also estimated.

Table 3 shows that in 2016 concentration of CO_2, SO_2 and NO_2 did not exceed the permissible limit but $PM_{2.5}$ concentration level exceeded the permissible limit during summer and pre-monsoon season. Table 4 shows that, in 2017 CO_2, SO_2 and NO_2 concentration level were not exceeded in all seasonal variation with the prescribed value but $PM_{2.5}$ concentration level exceeded with the prescribed value in winter season and summer season.

According to national ambient air quality standards, permissible limit of CO_2. SO_2, NO_2 and PM 2.5 was 4000, 80 , 80 and 60, respectively. Table 2 and 3 shows the statistical analysis of pollutants of study area during the year 2016 and 2017 respectively. In both years, PM 2.5 level exceeded its permissible levels as compared National Ambient Air Quality Standards.

Fig. 2 and 3 represents the calculated AQI level of pollutants in various weather conditions in 2016 and 2017. From 2nd & 3rd, it was identified that there was no dependency of pollutant in 2016 and 2017. As compared with table 2, the AQI of pollutants are falls under the moderate level of health concern in winter, summer and rainy season. In 2017, winter season only has the moderate level of health concern. The results revealed that the AQI level was not based on weather conditions. Therefore, emission sources plays important role in change of pollutants level in the study location.

The selection criteria for allergic conditions such as eye and nose irritation was that person should have been resident of Manali at least five years. Exclusion criteria defined as those who were presenting with mild symptoms and with recent duration of time and, if they residing at Manali, Chennai within past 5 years were exempted from this study. Controls were selected keeping in view that the controls were having similarities to cases as possible, except that study people were not presenting with allergic disease. Residents of Manali, Chennai, after as sorting, selected based on the inclusion and exclusion criteria were involved in the study after detailed explanation and with an informed consent. The case and control were selected 1:2 ratio. A total number of required sample size was around 420. The sample size we chose and analyzed is around 652. Case-control study in terms of odds ratio shown in Table 5. The odds retio measure the strength of association risk factor exposure and the disease resulting from it. A self-compiled questionnaire was prepared international standard questionnaires which will be distributed to subjects after translating in their local language to collect and assess data about their health issues and all relevant information of exposure. It is designed in such a way that it can be assessed among different age group.

Table 1: Criteria of air quality index

Air Quality Index	Levels
0 to 50	Good
51 to 100	Moderate
101 to 150	Unhealthy for sensitive groups
151 to 200	Unhealthy
201 and above	Hazardous

Table 2 : Seasonal variations of pollutants (µg m^{-3}) during Manali in 2016 with AQI

Season	$PM_{2.5}$	CO	SO_2	NO_2	AQI
Winter	58.49	2.98	27.28	10.63	54.8427
Summer	95.05	1.51	26.93	12.06	61.226
Monsoon rainy	45.03	1.24	24.1	18.8	39.9188
Pre-monsoon	94.2	1.35	22.6	14.2	59.1875

Table 3: Seasonal variations of pollutants (µg m^{-3}) in Manali during 2017 with AQI

Season	$PM_{2.5}$	CO	SO_2	NO_2	AQI
Winter	67.28s	2.39	30.76	23.08	59.7958
Summer	79.86	1.09	23.62	11.27	50.9906
Monsoon rainy	57.68	1.53	20.37	11.62	43.5927
Pre-monsoon	44.9	0.8	21.16	8.82	33.0771

Table 4: Case-control study (odds ratio)

	Allergic disease present (Cases)	Allergic disease absent (Controls)
Exposure present (exposed to air pollution)	198	290
Exposure absent (not exposed to air pollution)	18	144
Total	216	434

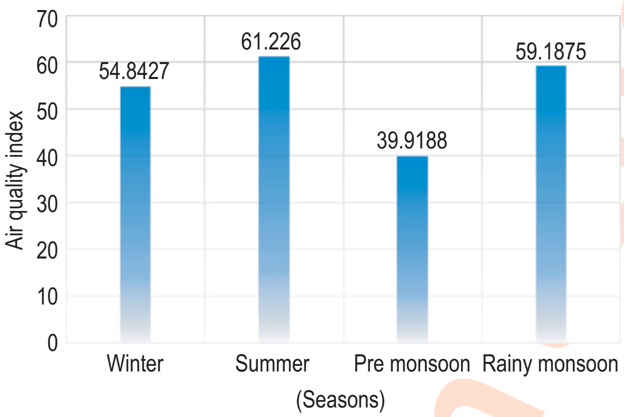

Fig. 1 : Seasonal variations of air quality index of Chennai in 2016.

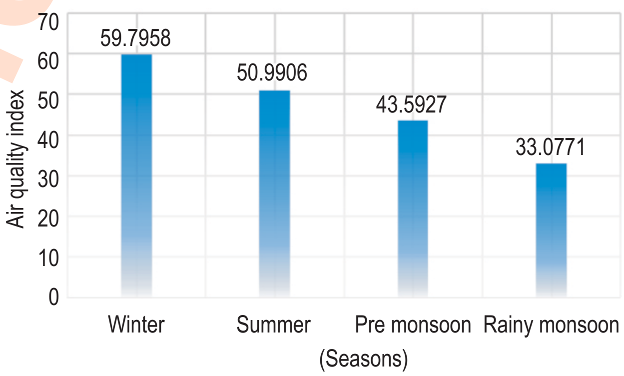

Fig. 2 : Seasonal variations of air quality index of Chennai in 2017.

From the details collected, the spread sheet was made and data were interpreted manually. The routine basic statistical method is used in the above case and control study after applying values in 2*2 table and odds ratio was estimated. Further statistical significance was derived using openepi software. From the statistical analysis, it is identified that the odds ratio of exposure to air pollution and its outcome in the form of allergic conditions as explained earlier (i.e. allergic rhinoconjunctivitis) is 5.4. In epidemiological studies, odds ratio value >1 suggests a positive relationship between air pollution exposure and risk of allergy.

The odds ratio value of 5.4 suggests that sick people have 5.4 times higher odds than controls (healthy people) having previous history of exposure to air pollution (exposure present) and it is positive association between the air pollution exposure and allergic disease (outcome),which means increased exposure causes disease and disease incidences can be significantly reduced by preventing exposure to air pollution or reducing air pollution in atmosphere ,which implies impact of air pollution with health aspects of community.

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