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A STUDY ON ENVIRONMENTAL AND SOCIO-ECONOMIC ANALYSIS OF ARIYALUR CEMENT CITY, TAMILNADU, INDIA.

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ABSTRACT

The economic cost of urban air pollution is measured by considering household health production function model which consists of health production function, demand function for mitigating activities and demand function for averting activities. To supplement the analysis of cost of illness approach, the WTP based on the contingent valuation survey is also employed. The ordered logistic regression model is used to analyze the factors affecting willingness to pay for reducing urban air pollution. The total suspended particulate matter (TSPM or PM10) and the respirable suspended particulate matter (RSPM or PM2.5) are considered as criteria pollutants. It is found that PM10and PM2.5 concentration has exceeded the NAAQS in all the monitoring stations of study area. It is two to three times higher than the average annual standard.

INTRODUCTION

The environmental quality is an important determinant of human health. Deterioration of environmental quality severely impacts quality of life and compromises the objective of sustainable development (World Health Organization, 1997). The exploitation of natural resources, beyond their carrying capacity, to fulfill human greed has curtailed essential ecosystems functions such as availability of oxygen, water, soil nutrient, pristine biodiversity, etc. With world population projected to be

9 billion by 2050, from the current 6 billion, the potential environmental damage is obvious and hence, needs urgent attention.

Air pollution is a form of environmental deterioration and is defined as ‑an undesirable state of the natural air, contaminated with harmful substances as a consequence of human activities. It is a public bad that results from emission generated by manufacturing process, associated with production and consumption of natural goods (Cropper and Oates, 1992). In economic parlance, there will be an uncompensated human welfare loss in the form of an external cost (i.e. health damage, mortality, morbidity etc) due to increasing exposure to toxic air emissions (Turner et al., 1994). But these costs are not accounted in the existing market system and results in market failure or missing market for environmental goods. The economists attribute the problem of environmental degradation to the presence of externality caused due to market failure.

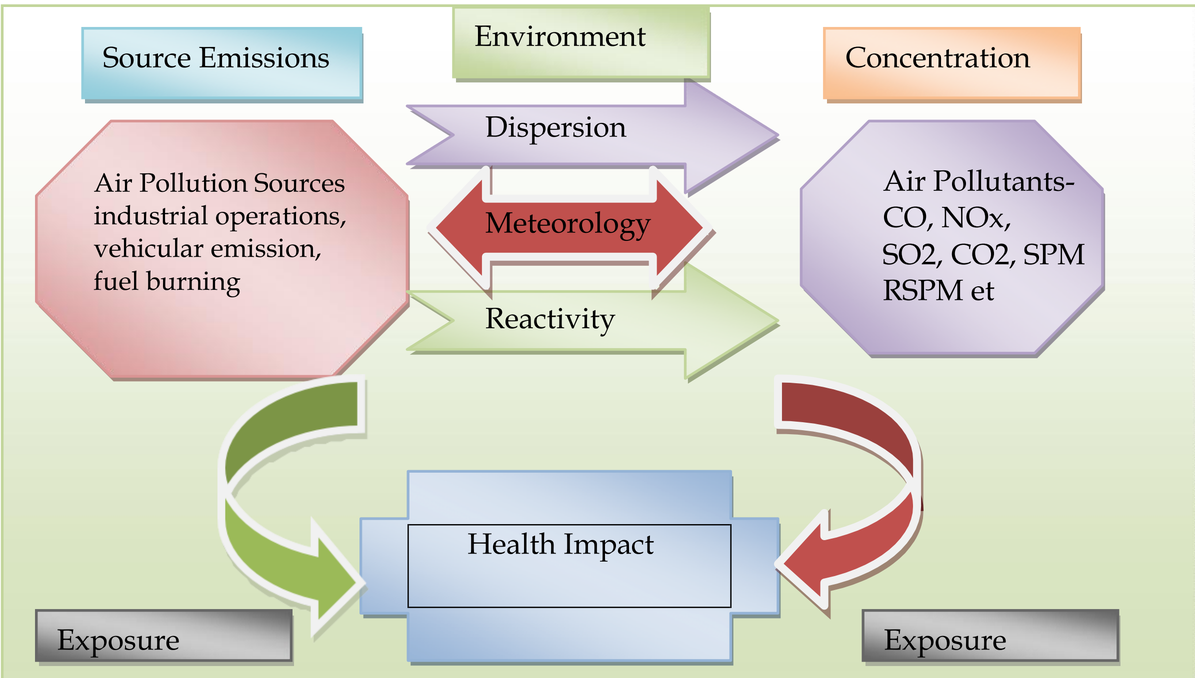
Coase (1960) defines the externality as ‑the problem of social cost. The social cost is the total cost associated with an economic activity. It includes costs borne by the economic agent and the cost to be borne by the society at large. This is the cost to compensate the past damage, to prevent the future damage and cost paid to meet the environmental damage at present. The environmental externalities are unreimbursed costs and uncharged benefits accruing to people, as a result of someone else's action in any production and consumption process. Internalizing this negative externality necessitates estimation of cost of environmental damage. Because polluted environment impoverishes quality of life, causes loss of human productivity and imposes higher healthcare costs. It is estimated that poor environmental quality is responsible for 25 percent of all ill health in the world today (WHO, 2007). This implies that natural environment plays a decisive role in ensuring better quality of life, when compared to socio-economic factors.

Urban Air Pollution

The urban air pollution is the byproduct of rapid urbanization, high demand for fossil fuel and exponential growth of vehicles. The United Nations Environment Programme (UNEP) has estimated that globally 1.1 billion people breathe unhealthy air (UNEP 2002). Epidemiological studies also show that, the concentration of pollutants like Particulate matter (PM), oxides of nitrogen (NOx), ozone (O3) etc., are associated with a wide range of health effects on human, especially on the cardio-respiratory system (Ostro *et al.,* 1995, Pope *et al.,* 2002). The urban air pollution is responsible for 800,000 deaths and 4.6 million losses of life years each year around the globe (WHO, 2003). The burden of disease attributable to outdoor air pollution causes 39 percent of loss of life years in South-East Asia and 20 percent in other Asian countries (WHO, 2004).

Therefore, studies have stressed the urgent need for efficient air quality monitoring and management to reduce adverse effects of urban air pollution on human beings and material (Sharman, 1996). With the increase in air pollution, the society is incurring high environmental cost in the form of environmental management and pollution control. The estimation of economic cost in the form of ill health, loss of productivity, depleted natural resources and reduced recreation of nature will help to determine the most efficient way to impose urban air quality standards and also to compare the cost of environmental damage to the cost of mitigation (World Bank, 2000).

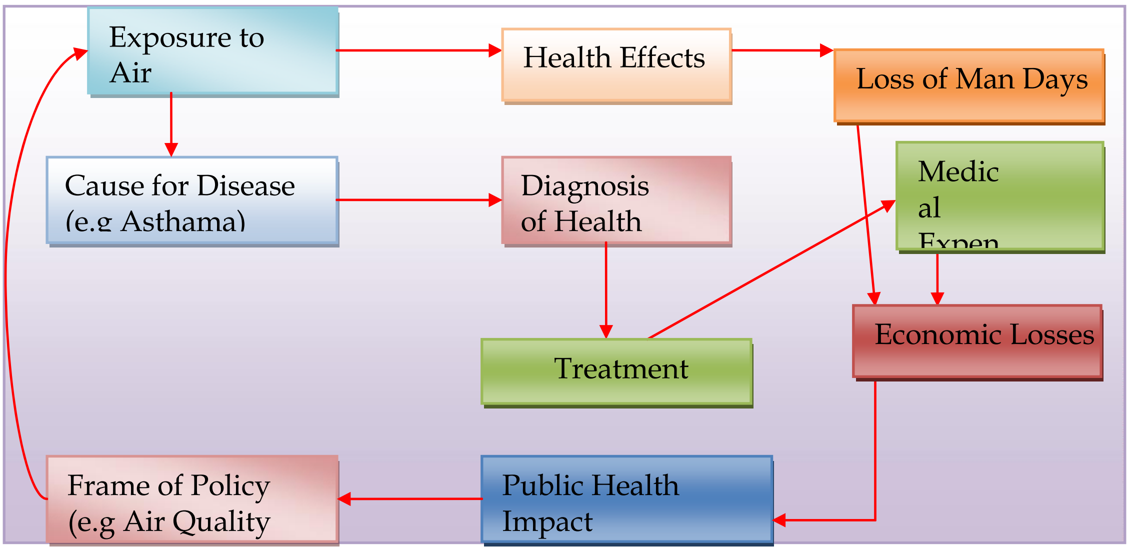
Fig 1: Dynamics of urban air pollution.



Health Impact of Urban Air Pollution

Continuous or long-term exposure to air pollutant causes respiratory illness. The health impact depends on exposure time i.e. for a short period of time (e.g., an accidental spill), repeated exposures for short duration, continuous exposure for long period and combination of all. Health impact assessment will help in policy formulation to abate air pollution and to improve the public health. Fig .2 illustrates the interlinkages of urban air pollution health impact and economic loss.

Fig 2: Inter linkages of urban air pollution, health impact and economic loss.



The health impact of urban air pollution is a complex phenomenon (Smith et al., 1999). The epidemiological studies have provided strong evidence that increase in air pollutant concentration causes health damage and productivity loss (Kunzli *et al*, 2000, Pope *et al.* 2002, Lvovsky *et al.*, 1998, Ostro *et.al.*, 1995). It potentially causes the high incidence of illness among individuals, who are already affected or suffering from respiratory illness, leading to premature death. In addition to welfare loss, it also imposes economic burden interms of additional cost to the society such as direct treatment cost and efficiency losses due to increased number of sick leaves and reduced labour service (WHO, 2004).

A study by Sacratees (2009) estimates welfare loss due to the hazardous air quality of Chennai city. The loss of welfare was estimated using econometric methods like Logit and Tobit Models in order to introduce WTP to improve urban air quality. The total cost of medication was estimated to be Rs 58,98,087 (2009). It is concluded that if the present air pollution continues to exist in future, without taking preventive steps to control it, the society's health expenditure becomes a huge burden on the people. Table 1. summarize some of the studies conducted in the Indian context on economic analysis of air pollution.

Table 1: Studies on economic analysis of air pollution (Indian context)

Sl No	*Author*	*Year*	*Region*	*Methodology*	*Results*
1	Cropper *et al*.	1987	Delhi	COI approach with the US dose-response data.	Increase in air pollution concentration was associated with death and more life years to be lost.
2	Abubacker	1994	Tiruchanpalli Tamil Nadu	COI Approach.	The workers were affected by the fine dust and were suffering from respiratory illness and had high COI due to fine dust exposure.
3	Brandon and Homman	1995	All India	COI approach using dose - response from estern countries and HCA.	The study revealed the cost of inaction due to environmental degradation. The health cost and the productivity loss were high.
4	World Health Organization	1995	36 Cities of India	COI and HCA.	The economic loss due to air pollution alone is at US$ 2,102 million per year and consequent premature deaths at 40,351 per year. Major environmental costs from all sources have been estimated to be US$9,715 million per year in India amounting to 4.53 per cent of GDP.
5	Parikh *et al.*	1997	Mumbai	COI approach with data on air quality from pollution control board.	Provided the estimates of the health damages due to air pollution and argued that it could be a component in the national system of accounts.
6	Lvovsky *et al.*	1998	Mumbai	COI approach with the US dose–response data.	Based on 1992 inventory, amounted to US$150 million and it is about 3 per cent of their total individual income.
7	Indira Gandhi Institute of Development Research	1998	Chembur region of Mumbai	WTP and COI approach	For every 10 µg/Nm^3 increase in atmospheric sulphur dioxide concentration, the annual social and health costs has exceeded Rs 10 crore in Mumbai. People living in the Chembur area have spent as much as Rs 35 lakhs annually due to poor air quality.
8	World Bank	1999	India	COI approach with the US dose–response data.	The estimated environmental damage in the year 1992 amounted to approximately US$10 billion or Rs 34,000 crores, which is 4.5 per cent of GDP.
9	Markandaya and Murthy	2000	Delhi and Kolkata	HCA	The annual marginal benefit to a typical household is Rs 2,086 in Delhi and Rs 950 in Kolkata, if the level of SPM is reduced from the current average level to the prescribed safe level.
10	Kumar and Rao	2001	Haryana— Panipat Thermal Power Station	WTP approach	For a 67 per cent reduction in the level of ambient mean PM10 concentration, which is required to meet national and WHO standards, residents of Panipat are willing to pay on an average an amount that ranges from Rs 12 to Rs 53 per month.

11	Usha Gupta	2014	Kanpur city	WTP approach and COI.	The results revealed that representative individual from Kanpur would gain Rs 165 per year if air pollution was reduced to a safe 213 million.
12	Giri *et al.*	2007	Kathmandu valley area	Attributable fraction method.	Estimated the number of deaths associated with exposure to excess ambient PM10 in the Kathmandu valley area. The study reveals that 95 deaths out of 10,000 deaths are due to particulate pollution in the study area.
13	Sacratees	2009	Chennai city	WTP approach and COI.	The annual cost of health damage due to air pollution was estimated to be Rs 58,98,087.

Source: Edited by author

From the foregoing review of research studies, it is clear that increase in urban air pollution is associated with higher health risks among the people. Studies on economic costs of health impacts have established this fact by using COI approach and WTP approach. In recent years, the dose–response functions are well designed and used as baseline for conducting studies in developing countries. The studies have also used the epidemiological techniques to find out the health effects of urban air pollution and then analyze its economic cost. The objectives of the study are as follows to estimate the quantitative health benefits due to reduction of the pollutant concentration. To estimate the economic cost of health damage caused by urban air pollution.

DATA COLLECTION PROCEDURE

The general information on socio-demographic characteristics of the households, both in the study and control area, is obtained through structured questionnaire, which consists of the following information:

- **Socio-demographic characteristics:** Religion, age, sex, marital status, education, occupation, composition of household members and the size of the accommodation or house, years of staying in the same area or house.
- **Effect due to air pollution:** The time of travel on the road by the respondents, mode of travel, distance of travel, type of occupation.
- **Health stock measures:** Current health status (symptoms of acute illnesses linked to air pollution exposure) and mitigating and averting activities adopted by the members in a household. Its sub-sections contained information on individuals‘ past health stock (chronic diseases), their habits that affect health in general.
- **Presence of indoor air pollution:** The use of home or car air conditioner, type of fuel in the kitchen or bathroom, whether the house or office is adjacent to high traffic junction, home or office affected by road

dust, type and amount of ventilation, use of mosquito repellent, incense burning.

- **Environmental awareness:** Perceptions on extent of pollution, causes of pollution, knowledge about type of air pollutants and general awareness of households about the illnesses that are caused due to air pollution.

RESULTS AND DISCUSSIONS

The socio-economic and demographic data of 506 households in the study area and 100 households in the control area are collected to facilitate comparison between the two groups for further analysis of the COI. Understanding the socio-economic and demographic variables is necessary as they are associated with the disease condition of the members of household in both study area as well as in the control area. Further, it is helpful for making conclusion in the analysis of data. Therefore, these profiles have a significant impact on the overall results of the study. The following results give the detailed analysis of environmental, socio-demographic profile of the study and control area.

Characteristics of the Households

The respondents from the households in the study and control area are earning members of the household, and in their absence immediate head of the households are interviewed. It is assumed that the respondents have a sufficient knowledge about urban air pollution and its consequent health impacts and are aware of the situation to elicit the household preference of *WTP* to reduce urban air pollution (WTP value). The members of households have either directly experienced the negative effect of the high urban air pollution or are aware about the problem.

Demographic Profile of the Household

Based on the primary data, demographic profile of the study and control area household is analyzed. The following results explain the gender, marital status, educational status, occupational status and monthly income of the study and control area households. Table 2 shows the demographic distribution of the respondents in the study and control area in terms of gender and marital status.

Table 2: The socio-economic and demographic profile of the households in the study and control area (in per cent)

Sl No	*Particulars*		*Study Area*	*Control Area*
1	Sex	Male	90.51	56
		Female	9.49	44
	Total		**100**	**100**
2	Marital Status	Married	72.53	84
		Unmarried	27.47	16
	Total		**100**	**100**

Source: Primary data.

The gender distribution shows that approximately 91 per cent are male respondents in the study area and 56 per cent in the control area. Significant proportions of the male respondents are from the study area. The female respondents constitute less in the study area when compared to the control area (only 9 per cent when compared to 44 per cent in the control area). Male and female respondents in the control area are comparable as it is 56 per cent and 44 per cent in the study area. It is an important factor that indicates the susceptibility and the resistance of the respondents to various air pollution induced respiratory diseases. This also indicates that the urban air pollution problem is equally perceived by male and female respondents.

It is further observed that a significant proportion of the respondents (84 per cent and 73 per cent) are married in the control and study area. This confirms that there is no significant difference between the study and control area households in respect of marital status. Religion is not included in the present study as most of the households are Hindus and can perceive the issue equally. The average size of the family in the control area is 4.46 and in the study area it is 4.06; hence, the difference in the family size between these areas is statistically not significant.

The age distribution of respondents in the study area is 15–68 years, whereas lower and the upper age group are 20–65 years in the control area. It is an important factor that determines the susceptibility of people‘s exposure to high concentration of air pollution and its consequent health impact. Age is also an important variable that determines the household‘s WTP as young people earn more when compared to old age people. Age is also a deciding factor about the susceptibility to air pollution induced disease. The age composition of the respondents in the study and the control area is given in Table 3**.**

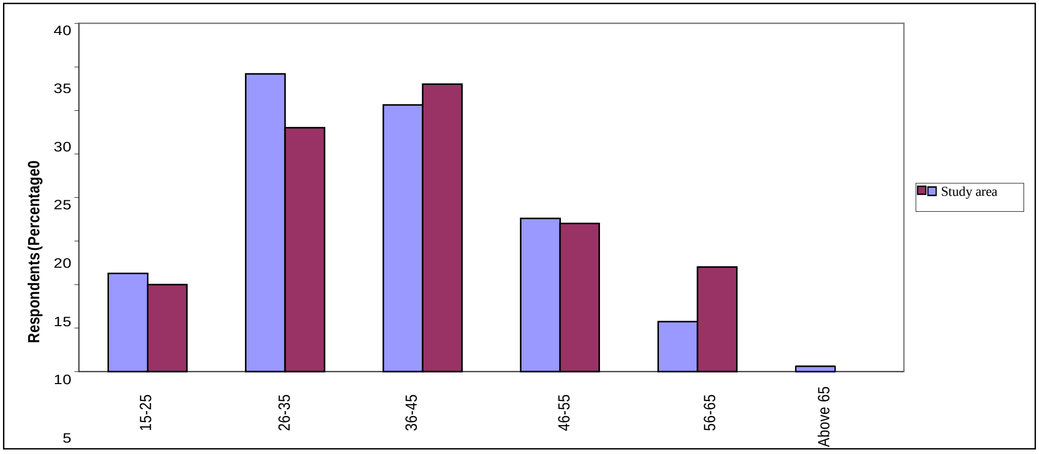
Table 3: Age distribution of the respondents in the study and control area

Sl No	*Age in Years*	*Study Area (Percentage)*	*Control Area (Percentage)*
1	15–25	11.26	10
2	26–35	34.19	28
3	36–45	30.63	33
4	46–55	17.59	17
5	56–65	5.73	12
6	Above 65	0.59	0
	Total	**100**	**100**

Source: Primary survey.

It is observed from Table 3 that 34 per cent and 31 per cent of the respondents in the study area fall between the age group of 26–45 years and 28 per cent and 33 per cent of respondents fall within this group in the control area. Hence, it is concluded that more than 65 per cent of respondents in the study area and 61 per cent of the respondents in the control area fall within the middle-aged group and can perceive the problem of air pollution induced health impacts. This also indicates that the households have sufficient knowledge to take decisions on different issues such as stating the WTP value and to take preventive and mitigative measures to protect themselves from illness. The group in the middle-aged category is almost similar and is statistically not significant as a majority of members of the households in both the locations belonged to the age group of 26–45 years. The age distribution in the study and control area is illustrated in Figure 3**.**

Fig 3: Frequency of age distribution of the households in the study and control area.



Source: Primary data.Education is another major indicator that determines the decision-making strategy on the issue and can significantly contribute towards eliciting the values for WTP. This also helps to understand the problem better and perceive the same to obtain suitable solution. Table 4 gives the education status in the study and control area.

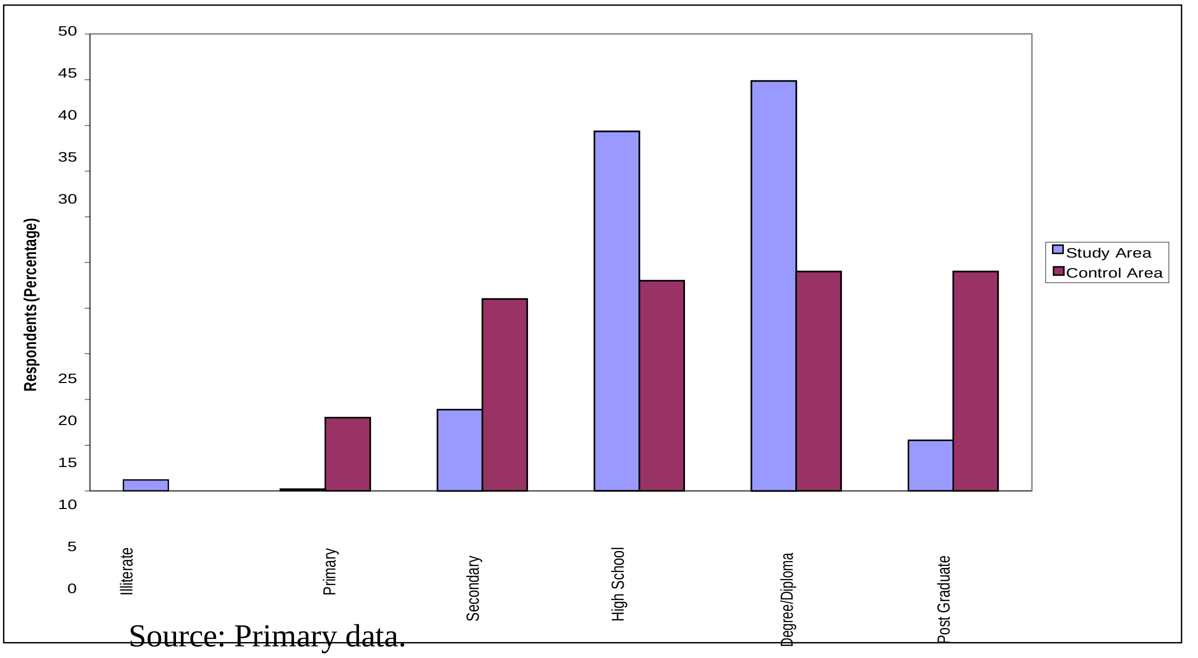
Table 4: Educational level in the study and control area

Sl No	*Education Level*	*Study Area (Percentage)*	*Control Area (Percentage)*
1	Illiterate	1.19	0
2	Primary	0.20	8
3	Secondary	8.89	21
4	High school	39.33	23
5	Degree/Diploma	44.86	24
6	Post-graduate	5.53	24
	Total	**100**	**100**

Source: Primary data.

Approximately 45 per cent of the respondents in the study area have completed degree/diploma, whereas in the control area it is 24 per cent. In the study area, 39 per cent of the respondents have qualification up to high school, whereas it is 23 per cent in the control area. Respondents who have studied up to post-graduation in the control area is 24 per cent, whereas it is only 5 per cent in the study area. The education profile shows that respondents can perceive the air pollution as a problem and are aware of the fact that increase in air pollution causes health effects. This also eliminates the strategic bias while answering the WTP value for mitigating the air pollution. The distribution of educational qualification in the study and control area is illustrated in Figure 4**.**

Fig 4: Educational status of respondents in the study and control area.



Source: Primary data.

The primary data shall be arranged to facilitate the comparison between different sets, clearly showing the different points of agreement and disagreement. The data shall be arranged in groups or classes according to their resemblances and affinities, which give an expression to the unit of attributes that, will subsist among diversity of individuals. This will also enable to perceive the ability of respondents on the specific issue of urban air pollution and their willingness to spend money towards preventive measures and affordability of treatments to come out of specific illness.

Hence, classification is done for different occupation by the respondents indicates that 39 per cent of the respondents in the study area have occupation as non-executives in the private companies, whereas in the control area it is 9 per cent. Respondents who are employed with government as non- executives in control and study area are 32 per cent and 12 per cent, respectively. Respondents in the study area are working as drivers at various organizations are 20 per cent and it is only 5 per cent in control area.

Spatial Distribution of Air Pollutants

Ambient air quality is considered as the environmental variable in the health production function to quantify the economic impact of increased urban air pollution on human health. We assume that individuals are aware of air quality levels, pollutant concentrations and their health risks (Manju et.al., 2000, Sundar et.al., 2000, Anandan et.al., 2019, Ashok et.al., 2018 & 2019, Vasanthy and Jeganathan 2008 & 2009). The Total Suspended Particulate Matter (TSPM- PM10), and Respirable Suspended PM (RSPM – PM2.5) are considered as criteria pollutants in the present study. The data on the air quality for the period from 2014–2019 are collected from Ariyalur and are compiled for all the air quality monitoring stations for the study as well as for control area. The detailed analysis of different monitoring stations is presented in all the monitoring stations in the study and control area are presented in Table 5.

Table 5: The average ambient air quality data (2014–2019) for monitoring stations in the study area and control area

Sl No	*Location*	*Pollutant concentration in µg/m³*			
		PM10	*PM2.5*	*SO2*	*NOx*
1	Anna Nagar	191.3	68.8	15.6	41.8
2	Maruthi Nagar	185.9	64.7	16.2	41.6
3	Housing Board	265.7	98.3	18.4	41.1
4	Ariyalur	273.9	104.4	16.6	40.6
5	Valaja Nagaram	141.27	67.29	16.89	39.5
6	Thouthaikulam	45.55	16.42	4.10	9.63
7	Allinagaram	9.82	4.25	6.84	14.21
8	Railway Gate	16.26	5.54	2.84	16.1
	AAQM Standard	**60**	**40**	**50**	**40**

Source: Author (2019).

Table 5 reveals that the PM10 and PM2.5 concentration exceeds the NAAQS (annual average) in all the monitoring stations except for control area. At the control areas, the PM10 concentration is within the prescribed standard for 24 h weighted average. Generally, in all the monitoring stations of the study area, the PM10 concentration is three to four times higher than the average annual standard. Similarly, the concentration of PM2.5 is also exceeding the NAAQS (annual average) in all the monitoring stations except for the control area and it is two to three times higher than the average annual standard.

The SO_2 concentration is below the standards (including the control area) due to reduction of sulphur content in the fuel (from 0.50 PPM to 0.025 PPM through desulphurization process). The NOX concentration is slightly higher than the NAAQM standard in three monitoring stations and is lower than the standard in the control area. The variation of critical pollutants (PM10 and PM2.5) in all the monitoring stations.

The time series analysis of RSPM is carried out for the year 2010 in order to know the ambient air quality trends and forecast of pollutant variation at all the monitoring stations using statistical software, Minitab 15.

The air quality map from the Arc view GIS 3.2a for an RSPM pollutant is obtained. The air quality atlas of RSPM for annual variation for the year 2019 at different air quality monitoring stations. The air quality status is expressed in terms of exceedence factor (EF) in the form of *low, moderate, high and critical levels.*

Table 6 shows the annual variation of RSPM at various AAQM stations of both study and control area for the period 2014–2019 based on the EF. The extent or the level of concentration of pollutant is presented in terms of low, moderate, high and critical EF.

Table 6: Classification of RSPM (based on the EF) at various AAQM stations for the period 2014–2019

AQMS Year	*Ariyalur*	*Anna Nagar*	*Valaja Nagaram*	*Housing Board*	*Maruthi Nagar*	*Thouthaikulam*	*Allinagaram*	*Railway Gate*
2014	H	C	H	H	H	-	L	-
2015	C	H	C	C	H	-	L	-
2016	C	H	H	C	H	L	L	L
2017	H	H	C	C	H	M	L	L
2018	H	H	C	C	H	M	L	L
2019	H	C	C	C	H	M	L	L

Note: L = low pollution; M = moderate pollution; H = high pollution; C = critical pollution. Source: TNPCB, 2019; Calculation: author.

It is observed that the concentration of RSPM exceeds the prescribed NAAQ standard of 60µg/m^3 at all the stations for the study area for the period 2014–2019, except for the control area. The minimum and maximum annual average value of RSPM is in the range of 46–264 µg/m^3. The critical level of pollution is observed at Ariyalur, Housing Board and Valaja Nagaram during 2018 and 2019, respectively. This critical concentration of RSPM is due to the industrial activity prevailing in the area along with increased movement of vehicles.

At Housing Board the pollutant concentration is due to the construction of flyover and BMTC bus terminal at the circle apart from high vehicular movement. At Valaja Nagaram it is due to commercial activity. However, the pollutant concentration varies due to high temperature, prevailing wind velocity and atmospheric instability. The lowest concentration is observed at Allinagarm, which is away from the city limit and is largely residential area without much vehicular movement. There are no major commercial activities here.

CONCLUSION

From the detailed analysis of the data on different environmental and socio-economic parameters, the following conclusions can be drawn: The ambient air quality analysis in the study area reveals that the pollutant concentration (RSPM and SPM) is exceeding the NAAQ standard. The extent or level of pollutant concentration is moderate to critical based on the EF in the study area, whereas it is low in the control area. It is observed that the background socio-economic and demographic characteristics are similar for the study and the control area households, except for pollution level, type of disease with which they are suffering and the health expenditure incurred. This is because the respondents in the study area are exposed to high concentration (two to three times higher than the standard) of air pollutants for longer time, when compared to the respondents from control area. The housing pattern and living conditions, income and family expenditure patterns and the occupation for both the groups were found to be similar.

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