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AN EMPIRICAL ANALYSIS OF AIR POLLUTION AND ITS EFFECT ON HUMAN HEALTH IN MADURAI CITY

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ABSTRACT----------

Air pollution is a wide-reaching problem and it is likely to influence the health of human populations is great. Human health is largely affected by the environmental. Death and human diseases are largely linked to air pollution patterns. This study was conducted with an objective to analyse the sources and effects of air that creates air pollution and to discuss the relationship between the air pollution and its effect on human health in Madurai city. The main sources of air pollution are industries, automobiles, coal combustion and electrical power plant. Major effects of air pollution include eye irritation, nose irritation, running nose, sore throat, coughing and wheezing. The empirical study is based on the sample survey of the city of Madurai. A total of 150 respondents were interviewed personally. The sample respondents a cross-section of different age groups, sex, educational levels, income levels of respondents and therefore it could be treated as a representative sample for such an exploratory study in Madurai city. The analysis has been carried out with the help of percentage method, chi-square test and Garrett's ranking method. Generally, the suitable action will be taken to control air pollution. Public education appears to be the best method as suggested by the respondents. However, government and NGOs can play a significant role in this process.

KEYWORDS: *Air pollution, Pollutant, Human health, Effects.*----------

INTRODUCTION

The introduction highlights the urgency of addressing air pollution as a significant environmental and human health concern. It emphasizes the importance of understanding its origins, constituents, and health implications to make informed decisions for policy interventions (Gul and Das, 2023). Air pollution entails the alteration of natural features of in indoor or ambient environment due to the release of biological, chemical, or physical substances (Azimi M.N. and Rahman M.M. 2024). Air pollution is both global and national problem as air pollutants released in a particular country can migrate through to the atmosphere and pollute the air elsewhere. We breathe from the moment of birth to our death. Breathing is of vital and constant importance for almost any living being on Earth, not just for us. The poor air quality affects all of us. It damages our health and the environment causing severe losses. The air we breathe comprises various pollutants (Veselina R. Ivanova 2020). Air pollution is a widespread problem in Madurai city. Clean air is considered to be a basic requirement for human health and other living beings (Tasica et al., 2008). Human health is largely affected by the environmental (Khademi et al., 2010). The mechanization of human life has never been without complications. Amongst these consequences air pollution is an increasing concern. The rising levels of air pollution in large cities seriously threaten the health of their residents (Masgedi et al., 2001). Death and human diseases are largely linked to air pollution patterns (Mohamadi 2006). This issues is receiving much attention, due to the fact that both in developed and developing countries there has been increase in urbanization due to higher activities in transportation and industrialization (Abiye et al., 2013). According to Mishra (2003) rapid growth in urban population, increasing industrialization and rising demands for energy and motor vehicles are the worsening air pollution levels. He added that air pollution is caused of ill health and death by natural and man- made sources, major man-made sources of ambient air pollution include tobacco smoke, combustion of solid fuels for cooking, heating, home cleaning agents, insecticides industries, automobiles, power generation, poor environmental regulation, less efficient technology of production congested road, and age and poor maintenance of vehicles. The World Health

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Organization (WHO) stated the urban air pollution as a critical public health problem, and more than 2 million premature deaths each year can be attributed to the effects of urban outdoor and indoor air pollution (WHO, 2006). The adverse health effects, such as respiratory morbidity, cardiovascular diseases and mortality, have created a public awareness to the urban air pollution (Colls and Micallef, 1997). The epidemiology and laboratory studies also demonstrated that ambient air pollutants (for example, PM, O_3, SO_2 and NO_2) contributed to various respiratory problems including bronchitis, emphysema and asthma (Ling et al., 2012). Enger and Smith (2000) also stated that people produce in large enough quantities that it interferes with our health or well-being. Air pollution is physical or chemical changes brought about by natural processes or human activities that result in air quality degradation (Cunningham et al., 2005). Air pollution means the presence in the outdoor atmosphere of one or more contaminants such as dust, fumes, gas, mist, odour, smoke or vapor in quantities, of characteristics and of duration such as to be injurious to human, plant or animal life or to property or which unreasonably interferes with the comfortable enjoyment of life and property (Kanagasabai, 2010). Although a number of physical activities (volcanoes, fire, etc.) may release different pollutants in the environment, anthropogenic activities are the major cause of environmental air pollution. Hazardous chemicals can escape to the environment by accident, but a number of air pollutants are released from industrial facilities and other activities and may cause adverse effects on human health and the environment. The effects of air pollution on the environment are same as any other pollution is harmful to the environment as well as human beings. The adverse health effects associated with urban air pollution, which include respiratory morbidity, cardiovascular diseases and mortality, have contributed in creating public awareness in this kind of pollution (Coils and Micallef, 1997). The health effects mentioned regarding the bad air pollution in these cities are chronic coughing and susceptibility to infections, while deaths from air pollution occur primarily among the elderly, the inform, and the very young. Bronchial inflammations, allergic reactions, and irritation of the mucous membranes of the eye and nose all indicate that air pollution must be reduced (Enger and Smith, 2000). Cunningham (2005) stated that, air pollution cause health effects by inhalation, or direct absorption through the skin or contamination of food and water. These air pollutants elements are very strong oxidizing agents, sulfates, SO_2, NO_2 and O_3 act as irritants that damage delicate tissues in the eyes and respiratory passages. This study was conducted to analyse the relationship between air pollution and health effects in Madurai city.

Objective of the study

The aim of this study is to formulate the relationship between human health and air pollution in an urban region, city of Madurai. In order to achieve the aim of the research, two objectives have been formulated, these are:

- To analyse the sources and effects of air that creates air pollution
- To discuss the relationship between the air pollution and its effect on human health in Madurai city.

LITERATURE REVIEW

Hegelund E.R. et al., (2024) to analyse the air pollution and human health: a phenome-wide association study. This study aims to explore the associations of long-term exposure to air pollution with onset of all human health conditions. This study was based on a Danish nationwide sample originally conceived and designed for inclusion in the Effects of Low-Level Air Pollution: A Study in Europe project. Health outcomes were measured using information on all health conditions registered in the Danish National Patient Register and all underlying causes of death in the Danish Register of Causes of Death. Furthermore, PM2.5 and NO2 were both positively associated with so far unexplored, but highly prevalent outcomes relevant to public health, including senile cataract, hearing loss and urinary tract infection. The findings of this study suggest that air pollution has a more extensive impact on human health than previously known. The study revealed that the first of its kind to investigate the associations of long-term exposure to air pollution with onset of all human health conditions, further research is needed to replicate the study findings.

A study was conducted by Wang et al., (2022) to explain that the air pollution and human health: investigating the moderating effect of the built environment. Air pollution seriously threatens human health and even causes mortality. It is necessary to explore effective prevention methods to mitigate the adverse effect of air pollution. Shaping a reasonable built environment has the potential to benefit human health. In this context, this study quantified the built environment, air pollution, and mortality at 1 km × 1 km grid cells. The moderating effect model was used to explore how built environment factors affect the impact of air pollution on cause-specific mortality and the heterogeneity in different areas classified by building density and height. Consequently, we found that greenness played an important

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role in mitigating the effect of ozone (O_3) and nitrogen dioxide (NO_2) on mortality. This study can provide support for urban planners to mitigate the adverse effect of air pollution from the perspective of the built environment.
Isabella M. Errigo et al., (2020) this study explored that the human health and economic costs of air pollution in Utah: An expert assessment. The study focused on air pollution causes more damage to health and economy than previously understood, contributing to approximately one in six deaths globally. However, pollution reduction policies remain controversial even when proven effective and cost negative, partially because of misunderstanding and growing mistrust in science. The study focused on an expert assessment to bridge these research–policies divides in the State of Utah, USA, combining quantitative estimates from 23 local researchers and specialists on the human health and economic costs of air pollution. This study conclusion that the combining quantitative assessments from local experts is a responsive and cost-effective tool to increase trust and information uptake during time-sensitive policy windows.
According to Sang-Young Eom et al., (2018) this study highlighted that the health effects of environmental pollution in population living near industrial complex area. It was evaluated the effects of pollution from industrial complex on human health, the study has performed a pooled analysis of environmental epidemiologic monitoring data for residents living near national industrial complexes. The industrial complexes were found to have more respiratory symptoms, such as cough and sputum production and sputum's of atopic dermatitis.

An attempt has been made by Kesavachandran C.N., et al., (2015) to identify the particular matter in ambient air and its association with alternations in lung functions and respiratory health problems. It was observed that the association between PM concentration and respiratory health risks among outside exercisers. The study was concentrated the agricultural laborers, anganwadi (child care) workers, beauty parlor workers, haircutting saloon workers, small business proprietors, dairy and livestock workers, gardeners, health care workers and housewives. The study revealed that the outdoor exercisers in locations with Pm concentrations are at a risk of lung function impairment. These impairments are due to deposition of Pm in the smaller and larger airways.

The study was carried out by Mabahwi N.A et al., (2015) to estimate that urban air quality and human health effects. This study was to identify urban air quality and human health level set in residential, traffic and industrial areas. The samples were selected from five major pollutants, such as sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Carbon Monoxide (CO), Particular Matter and Ozone (O_3). The adverse health effects associated with air pollution, which include respiratory, morbidity, cardiovascular diseases and mortality.

A study was undertaken by Rodriguez-Villamizar L.A et al., (2012) to study the effects of air pollution respiratory health in susceptible populations. In order to analyse the prescribed objective of the effects of exposure to three different levels of air pollution, measures in PM10 concentrations, on the respiratory health. In this study, concentration of socio- demographic variables (age, sex, length of time living in the area, educational level, occupation and type of health care system used), presence of indoor and outdoor pollutants (smoking, firewood, humidity, industry, construction site), personal and family medical background (asthma, respiratory symptoms measured by age group (infant, children and adults).

MATERIALS AND METHODS

Site and sample collection: Madurai city of Tamil Nadu was randomly selected for the present study. The city of Madurai lies on the banks of the Vaigai Rivers in the State of Tamil Nadu. It is the second largest city in the State after Chennai and Coimbatore and is a major cultural, educational and manufacturing center. Madurai has an area of 147.97 km^2 (57.13 sq mi) and is located at 9.9° North, 78.1° East. At present it has densely populated city in the southern state of India namely in Tamil Nadu. At most of the subsequent developments of the city were multiplied without a scientific planning, the air pollution sources are heterogeneous and widespread all over the city. This lead to the emission of different air pollutants and air pollution loads and hence different degrees of ambient air pollution are experiences with respect to various places of the city. Meteorology fields are important as they have a direct impact on air pollution concentrations. During periods of high precipitation or high speed winds, emissions from a city are swept away and do not have an impact on concentrations. On the other hand, during the winter months when temperatures and inversion heights are low, there is a greater impact of emissions on pollution concentrations. Low temperatures also affect behavior through the need for space and water heating-which in turn has increase emissions. The empirical study is based on the sample survey of the city of Madurai. This study used a questionnaire survey to gather the information related to air pollution and health effects in Madurai. A total of 150 respondents were

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interviewed personally. The sample represents a cross-section of different age groups, sex, educational levels, income levels of respondents and therefore it could be treated as a representative sample for such an exploratory study in Madurai city. The data was collected by using a structured questionnaire blended with suitable open-ended and close-ended questions. The analysis has been carried out with the help of percentages method on sources and effects of air, chi-square test to estimate the effects of air pollution and Garrett's ranking method on relationship between the air pollution and its effect on human health in Madurai city.

RESULTS AND DISCUSSION

A total of 150 respondents were participated in the study. To observe the effects of air pollution in different age groups, adults (more than 18 years) were included in the study. As the study focused on effects of air pollution on human health in Madurai city. Sources of air pollution in terms of age groups are depicted in Table 1.

Table 1. Sources of air pollution in terms of age groups

Sources of air pollution	Age Groups				Total
	Below 20	20-35	35-55	Above 55	
Industries	13 (8.67%)	11 (7.33%)	15 (10.00%)	12 (8.00%)	51 (34.00%)
Automobiles	11 (7.33%)	9 (6.00%)	10 (6.67%)	11 (7.33%)	41 (27.33%)
Coal Combustion	9 (6.00%)	10 (6.66%)	7 (4.67%)	10 (6.67%)	36 (24.00%)
Electrical Power Plant	7 (4.67%)	5 (3.33%)	7 (4.67%)	3 (2.10%)	22 (14.67%)
Total	40 (26.67%)	35 (23.33%)	39 (26.00%)	36 (24.00%)	150 (100.00%)

Source: Survey Data.

It is evident from Table1 that among 150 sample respondents, 51 (34%) respondents belong to the very large proportion of respondents in each age group is being affected by air pollution emanating from the industries. 41 (27.33%) respondents in each group is being affected air pollution emanating from the automobiles. 36 (24%) respondents belong to the medium proportion of respondents in each age group is being affected by air pollution emanating from the coal combustion. A relatively small proportion of 22 (14.67%) respondents acknowledge adverse effect of air generated by electrical power plant.

Table 2 presents that the percentage of male and female respondents affected by different sources of air pollution.

Table 2. Sources of air pollution affecting male and female respondents

Air sources	Male	Female	Total
Industries	31 (20.67%)	27 (18.00%)	58 (38.67%)
Automobiles	21 (14.00%)	13 (8.67%)	34 (22.67%)
Coal Combustion	20 (13.33%)	18 (12.00%)	38 (25.33%)
Electrical Power Plant	11 (7.33%)	9 (6.00%)	20 (13.33%)
Total	83 (55.33%)	67 (44.67%)	150 (100.00%)

Source: Survey Data.

Regarding the gender classification of the sample respondents in the two different categories with variations in degree of sources of air pollution, it was indicated from Table 2 that there were 31 (20.67%) males and 27 (18%) females in the high level of respondents is being affected by air pollution emanating from the industries. 21 (14%) males and 13 (8.67%) females respondents in each classification is being affected by air pollution emanating from the automobiles. It was comprehended that there were 20 (13.33%) males and 18 (12%) females in the medium level of respondents is being affects by air pollution emanating from the coal combustion. It was also comprehended that there were 11 (7.33%) males and 9 (6%) females in the low level of respondents is being affected by air pollution emanating from the electrical power plant. It was obvious from the generated table that the number of male respondents 83 (55.33%) was higher than that of the female respondents 67 (44.67%) in there different level with variations in degree of air pollution.

Environmental air pollution and effects on human health in terms of eye irritation, nose irritation, running nose, sore throat, coughing, wheezing and other related diseases was found and it has been presented in Table 3.

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Table 3. Effects of air on different age groups

Effects of air pollution	Age Groups			Total
	Below 20	20-35	35-55	Above 55
Eye Irritation	12 (8.00%)	10 (6.67%)	9 (6.00%)	11 (7.33%)	42 (28.00%)
Nose Irritation	7 (4.67%)	11 (7.33%)	6 (4.00%)	3 (2.00%)	27 (18.00%)
Running Nose	5 (3.33%)	3 (2.00%)	7 (4.67%)	9 (6.00%)	24 (16.00%)
Sore Throat	4 (2.67%)	1 (0.67%)	2 (1.33%)	5 (3.33%)	12 (8.00%)
Coughing	11 (7.33%)	4 (2.67%)	7 (4.67%)	6 (4.00%)	28 (18.67%)
Wheezing	3 (2.00%)	4 (2.67%)	6 (4.00%)	4 (2.66%)	17 (11.33%)
Total	42 (28.00%)	33 (22.01%)	37 (24.67%)	38 (25.32%)	150 (100.00%)

Source: Survey Data.

Table 3 revealed that the majority of 42 (28%) respondents in each age group is exposed to air pollution report occurrence of eye irritation problem. 27 (18%), 24 (16%) and 28 (18.67%) respondents belong to the medium proportion of respondents in each age group is being affected by air pollution report occurrence of nose irritation, running nose and coughing. A relatively small proportion of 12 (8%) and 17 (11.33%) respondents acknowledge adverse effect of air generated by sore throat and wheezing problems.

Table 4. Gender-based difference in perception of effects of air pollution

Effects of air pollution	Male	Female	Total
Eye Irritation	21 (14.00%)	19 (12.67%)	40 (26.67%)
Nose Irritation	19 (12.67%)	16 (10.66%)	35 (23.33%)
Running Nose	11 (7.33%)	10 (6.67%)	21 (14.00%)
Sore Throat	4 (2.67%)	3 (2.00%)	7 (4.67%)
Coughing	20 (13.33%)	17 (11.33%)	37 (24.66%)
Wheezing	6 (4.00%)	4 (2.67%)	10 (6.67%)
Total	81 (54.00%)	69 (46.00%)	150 (100.00%)

Source: Survey Data.

Table 4 shows that perception of male and female populations about the effect of air varies. It is illustrates that male respondents constitute 21 (14%) and female respondents constitute 19 (12.67%) in the high level of respondents is being affected by eye irritation emanating from air pollution. It was comprehended that there were medium level of respondents is being affected by nose irritation, running nose and coughing. It was also comprehended that there were low level of respondents is being affected by sore throat and wheezing. It was obvious from the generated table that the number of male respondents 81 (54%) was higher than that of the female respondents 69 (46%) in there different level with variations in effects of air pollution in human health.

Table 5. Effect of air pollution on health of the respondent in Madurai city

Opinion	Level of Air Pollution			TOTAL
	High	Moderate	Low	
Affected	27 (77.14)	51 (69.86)	13 (30.95)	91 (60.66)
Not Affected	8 (22.86)	22 (30.14)	29 (69.05)	159 (39.34)
Total	35 (100.00)	73 (100.00)	42 (100.00)	150 (100.00)

Source: Survey data.

Figures in brackets represent percentage to total.

Table 5 reveals that in the case of a high level of air pollution, out of 35 respondents, the majority of 27 (77.14 percent) sample respondents health has been affected due to air pollution, while the remaining 8 (22.86 percent) of them have not been affected due to pollution. In the case of moderate levels of air pollution, out of 73 sample respondents, the majority of 51 (69.86 percent) of the respondents are affected due to air pollution, while the remaining 22 (30.14 percent) of them are not affected. Out of 42 sample respondents from low levels of air pollution, the majority of 29 (69.05 percent) of those respondents are not affected due to air pollution, while the remaining 13 (30.95 percent) of them are affected. The database revealed that 91 (60.66 percent) of the respondents were affected and the remaining

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59 (39.34 percent) of the respondents were not affected by air pollution. The level of air pollution in the study area and its impact on residents could be correlated with the emissions from domestic activities, automobiles, and industries.**Null Hypothesis (Ho):** There is no association between affected on health and level of air pollution.

Table 6: Estimated chi-square test result: Effect an health vs. level of air pollution in Madurai city

Particulars	Estimated value
Calculated chi-square value	22.109
Table chi-square value at 5 percent level	5.991
Degrees of freedom	2
Inference	Significant

Since the calculated chi-square value is greater than the table value of chi-square with 2 degrees of freedom at the 5 percent level of significance, the formulated null hypothesis is rejected. Therefore, there is an association between effect on health and level of air pollution.

Henry Garrett's Ranking

Henry Garrett's ranking technique is used to evaluate the problems and converted the order of merit given by respondents into rank to find out the significant factors. It states the formula to calculate the score to find out the ranking (Dhanavandan, 2016). The outcomes of such ranking have been converted into score value by using the formula.

$$\text{Percent Position} = \frac{100(Rij-0.5)}{Nj}$$

Where

Rij = Rank given for the 'i'th variable by 'j'th respondents

Nj = Number of variables ranked by 'j'th respondents.

The percent position of each rank thus obtained was converted into scores using the table given by Garrett. The score of individual representing each reason were added together and divided by the total number of respondents. The mean values for all the problems were analysed. The mean score is the rank in descending order of magnitude.

The Garrett value of six major effects ranked by 150 respondents is summarized in Table 6. The Garrett value of 'eye irritation' has the value of 77 followed by 'nose irritation' with value of 63. Meanwhile, the 'running nose', 'sore throat', 'coughing' and 'wheezing' have the value of 54, 46, 37 and 23 respectively.

Table 6. Percent Position and Garrett Value

Sl. No	100 (Rij – 0.5) / Nj	Percent Position	Garrett's Value
1	100 (1 - 0.5) / 6	8.33	77
2	100 (2 - 0.5) / 6	25.00	63
3	100 (3 - 0.5) / 6	41.66	54
4	100 (4 - 0.5) / 6	58.33	46
5	100 (5 - 0.5) / 6	75.00	37
6	100 (6 - 0.5) / 6	91.66	23

A number of problems influence the respondents by air pollution. The problems are categorized into six. They are depicted in Table 7.

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Table 7. The relationship between the air pollution and its effect on human health problems of Henry Garrett Ranking method

Factor No	Effects	Score Values X	1	2	3	4	5	6	Total	Garrett Mean Score	Rank
1	Eye Irritation	F	30	31	29	26	14	20	8003	77	I
		Fx	2310	1953	1566	1196	518	460			
2	Nose Irritation	F	21	13	24	31	25	36	6911	63	VI
		Fx	1617	819	1296	1426	925	828			
3	Running Nose	F	19	24	31	27	25	24	7368	54	V
		Fx	1463	1512	1674	1242	925	552			
4	Sore Throat	F	31	18	23	34	27	17	7717	46	II
		Fx	2387	1134	1242	1564	999	391			
5	Coughing	F	29	24	19	21	36	21	7552	37	III
		Fx	2233	1512	1026	966	1332	483			
6	Wheezing	F	20	40	24	11	23	32	7449	23	IV
		Fx	1540	2520	1296	506	851	736			

Source: Survey Data.
Note: X=Scale value, F=Number of sample respondents, Fx=Score value.

The major health effects of air pollution are ranked by 150 respondents are summarized in Table 7. According to Table 7 indicates that eye irritation is the major health problems faced by the sample respondents with the mean score of 77 (I Rank) followed by sore throat with the mean score is 46 (II Rank), coughing with the mean score is 37 (III Rank), wheezing with the mean score is 23 (IV Rank), running nose with the mean score is 54 (V Rank) and nose irritation with the mean score is 63 (VI Rank).

SUGGESTIONS FOR CONTROLLING AIR POLLUTION

The following general measures should be taken to control air pollution. The allowable emission rate should not be exceeded by individual plant.

- A continuous air pollution survey should be conducted in the concerned area and its neighbouring region.
- Air pollution control technology should be incorporated through legal requirement into design of the individual plant.
- Meteorological conditions should be considered while deciding on the location of the industries.
- Vehicular emission standards should be setup.
- Quality of fuel should be improved. Use of ethanol blended petrol, biodiesel and Compressed Natural Gas (CNG) should be promoted as they cause less pollution.
- Use of non-fossil fuels and renewable energy sources such as solar energy, tidal energy, and hydro-energy should be encouraged.
- Industrial zone should be separated from living areas.
- Smoking should be banned in public places.

Essential approaches are used to control air pollution are:

- The best solution is to ensure that there is good combustion.
- The second technique is to use type of mechanical device.
- Chemical treatment.

CONCLUSION

The empirical study to explore that the environmental air pollution and its effect on human health in Madurai city. Cars, buses, planes, trucks, trains, power plants, oil refineries, industrial facilities, factories, wood burning fireplaces, wind-blown dust, wildfires and volcanoes are major sources of air pollution. Most of our day-to-day activities, by knowingly and unknowingly every one of us contribute to generate air pollution. Frequently ignored, air pollution

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adversely affects the human being leading to eye irritation, nose irritation, running nose, sore throat, coughing, wheezing and so on. In conclusion, human are responsible with the waste emitted to the air and society must take necessary actions to overcome the air pollution matter. Air pollution constitutes a grave danger for the healthy sustenance of all form of life on this earth. The first and foremost thing which deserves to be done is to educate the people that the atmosphere is not meant to dump all kinds of pollutants. Importance of preserving health and welfare of man, protection of plant and animal life, prevention of damage to property and maintenance of cleaner atmosphere environment should also be explained. This theoretical effort has to be accompanied by practical measures to control air pollution. The suitable action will be taken to attenuate the air and controlling pollution. Policymakers in developing countries need to design programs, set standards and take action to mitigate adverse health effects of air pollution. In future, public education, government and NGOs can play significant role in controlling the air pollution.

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