GENERAL CONSIDERATION

Climate change is the greatest threat of the 21st Century (UNDP Human Development Report 2007/2008). Recent extreme weather events caused serious health and social problems in Europe, particularly in urban areas. The global swarming is expected to have serious consequences for: Agricultural production; Biodiversity; Health and Sea Level rise, Health impacts, Heat-related illnesses (heat stroke and dehydration), Respiratory and cardiovascular illness. Physical and mental stress, Spread of infections, Spread of epidemics and vector borne diseases (diarrhoea, malaria).-Contamination of drinking water and food (IPCC, 2007).

Human health is strongly affected by social, political, economic, environmental and technological factors, including urbanization, affluence, scientific developments, individual behavior and individual vulnerability (e.g., genetic makeup, nutritional status, emotional well-being, age, gender and economic status). The extent and nature of climate change impacts on human health vary by region, by relative vulnerability of population groups, by the extent and duration of exposure to climate change itself and by society's ability to adapt to or cope with the change (Meehl *et al.,* 2000; Smith, 2000; Patz, 2001; McMichael and Kovats, 2000 and McMichael *et al.,* 2006).

There is growing concern about the links between the environment and health. Worldwide, and probably also in India, one quarter to one third of the burden of disease appears to be attributable to environmental factors. Vulnerability and exposure, however, vary markedly between different groups and areas, with children and the elderly being particularly at risk. There is reasonable understanding of cause-and-effect relationships between water, air pollution and human health. However, the health consequences of other environmental factors and exposures, such as those resulting from climate change and chemicals in the environment are a result of complex interactions between the environment and humans that are far less understood.

There is a steady, significant rise in the incidence of allergic and autoimmune diseases in developed countries over the past three decades. The main reason for the increased prevalence of allergic and autoimmune diseases in industrialized countries is the reduction in the incidence of infectious diseases. Infections can suppress allergic and autoimmune disorders (Bach, 2002).

Climate is defined as the sum of atmospheric elements and the variations occurring in them through parameters viz.: solar radiation, temperature, humidity, clouds and precipitation (type, frequency, and amount), atmospheric pressure, and wind (speed and direction) which are the main meteorological parameters.

Meteorology is the interdisciplinary scientific study of the atmosphere. Meteorological phenomena are observable weather events which illuminate and are explained by the science of meteorology. Those events are bound by the variables that exist in Earth's atmosphere; temperature, air pressure, water vapor, and the gradients and interactions of each variable, and how they change in time. Aristotle's Meteorologica (c.340 B.C.) is the oldest comprehensive treatise on meteorological subjects. Although most of the discussion is inaccurate in the light of modern understanding, Aristotle's work was respected as the authority in meteorology for some 2,000 years. In addition to further commentary on the Meteorologica, this period also saw attempts to forecast the weather according to astrological events, using techniques introduced by Ptolemy.

As speculation gave way to experimentation following the scientific revolution, advances in the physical sciences made contributions to meteorology, most notably through the invention of instruments for measuring atmospheric conditions, e.g., Leonardo da Vinci's wind vane (1500), Galileo's thermometer (c.1593), and Torricelli's mercury barometer (1643). Further developments included Halley's account of the trade winds and monsoons (1686) and Ferrel's theory of the general circulation of the atmosphere (1856). The invention of the telegraph made possible the rapid collection of nearly simultaneous weather observations for large continental and marine regions, thus providing a view of the large-scale pressure and circulation patterns that determine the weather. The complex methods require not only air temperature as meteorological input parameter but also other meteorological parameters that allow a more sophisticated description of the thermal situation such as, for example, humidity, wind speed, and cloud cover (Koppe and Jendritzky, 2005).

Meteorology, the science of studying the observable changes in the weather is often overlooked when dealing with health and yet it is one of the most critical elements of primary health care. (Simon, 2009). Meteorology is considered as a key to understanding the causes of air pollution in an area. The degree to which air pollutants discharged from various sources concentrate in a particular area depends largely on meteorological conditions. Even though the total discharge of contaminants remains constant from day to day; degree of air pollution may vary widely because of differences in meteorological conditions (Rao and Rao, 1989). Generally, the degree to which air pollutants discharged from various sources, concentrate into a particular area depends on meteorological conditions. So, the knowledge of these meteorological parameters which influence the dispersion process of air pollutants will give certain results like whether the air pollutants will be diluted in to the atmosphere or they just simply tend to concentrate on the ground.

Synergistic effects of meteorological variables and various pollutants on mortality has been suggested by various workers. Katsouyanni *et al.,* (1993) have reported for Athens and Greece that temperature; relative humidity; and SO_2 show positive interaction between heat and pollution; Sartor *et al.,* (1995) in their studies in Belgium have also reported that temperature; relative humidity; TSP; SO_2; NO; NO_2; ozone have positive interaction between heat and ozone. Since both meteorological variables and the concentrations of air pollutants vary on a daily basis, it is reasonable to address their mutual inter-relationship as well as the possible synergistic effect they may have on health (Katsouyanni*et al.,* 1993; Samet *et al.,* 1998; O'Neil, Zanobetti& Schwartz,2003). However, although it has been usual practice to adjust for meteorological variables (mainly temperature and humidity) when analysing the effects of air pollution, the adjustment for air pollutants when assessing the temperature effects has not been studied. Furthermore, the studies formally addressing the synergy between pollutants and meteorological variables are relatively few.

Asthma is a disease that has captured a great deal of attention for several years. One of the perplexing aspects to asthma is that the prevalence is increasing in most industrialized countries. The reasons for this widespread increase are largely unknown. Another aspect of industrialization is the persistence of air pollution in urban areas. Asthma is a worldwide problem and there is evidence that the prevalence is increasing, but there are still insufficient data to determine the likely causes for this increase. Although extensive evidence shows that ambient air pollution exacerbates existing asthma, a link with the development of asthma is less well established. This is primarily because few prospective studies with extensive exposure data have been conducted. However, in the past few years, some limited data sets have emerged to support associations between air pollution and incidence of asthma. The ambient air pollutants studied have included particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and ozone (O_3). Air pollution is often worse during hot weather. Because hot weather and air pollution often coincide, it can be difficult to separate the effects of the two. It is possible that hot weather and air pollution interact so that air pollution has greater health effects when the weather is extremely hot.

The incidence of asthma has increased dramatically over recent years in most industrialized countries of the world. Air pollution from motor vehicles has been implicated as one of the factors that are responsible for this increase (Pershagen *et al.*, 1995; Peters, 1996; Koenig, 1999; Venn *et al.*, 2000; Jedrychowski *et al.*, 1999; Gauderman *et al.*, 2000; Busse and Lemanske, 2001and Delfino, 2002). Epidemiological studies carried out in different geographical regions in the world have shown a significant and consistent association between ambient levels of pollutants and increased asthma and rhinitis symptoms. (Barnes, 1994; Brunekreef *et al.*, 1997; Guo *et al.*, 1999; Gold, 2000 and Yu *et al.*, 2000). Recent human and animal exposure studies, as well as laboratory-based studies, have demonstrated that diesel particles, ozone and nitrogen dioxide induce an inflammatory response that involves various inflammatory cells, mediators and adhesion molecules, which could contribute to worsening of the asthma. (Abbey *et al.*, 1998; Hirsch *et al.*, 1999; Krämer *et al.*, 2000 and Svartengren *et al.*, 2000).

Questionnaires are commonly used for assessing the effects pollutants on the health, as they are relatively cheap and allow pollutant exposure assessment during different time periods and in different indoor environments. (Daly and Taylor, 2004; Juniper *et al.*, 2000; 2005; 2006; Ehrs *et al.*, 2006; Delclos *et al.*, 2007; Pirkle *et al.*,1996; Riboli *et al.*,1990 and Jaakkola, 2000). Questionnaire-based assessment of environment pollutants exposure conducted in Finland (Jaakkola *et al.*,1994) and Californian young adults (California EPA, 1997) have proved to be very useful.A number of recent questionnaire surveys have estimated the prevalence of respiratory symptoms in children as well as adults. (Strachan *et al.*, 1998; Ninan and Russell, 1992; Ayres, 1973; Juniper *et al.*, 2000; Marks *et al.*, 2000 and Nathan *et al.*, 2004).

The first task for environmental health researchers and epidemiologists is to describe the 'baseline' relations between climatic conditions and health outcomes (a topic that has been largely ignored over the past half-century of 'modern epidemiology'). This helps in clarifying the sensitivity of each specified health outcome to variations in climatic conditions. Second, there is a need to seek evidence of ongoing changes in health risks and outcomes due to climate change – a complex task that is subject to all the usual difficulties of multivariate influences and causal attribution. Third, by forging new collaborations with climate scientists and mathematical modelers, health researchers must estimate how future scenarios of climate change are likely to affect health risks and changes in burdens of disease. Finally, of course, there are very important new research tasks relating to the prevention of adverse health outcomes. Where one can emphazise on what adaptive strategies can be introduced to lessen the risks (particularly for those segments of the population that are most vulnerable) from current and unavoidable weather changes.

Health effects associated with climate change pose significant risks for the elderly, who often have frail health and limited mobility. Older adults are more sensitive to temperature extremes, particularly heat (Semenza *et al.*, 1996 and Medina-Ramon *et al.*, 2006); individuals 65 years of age and older comprised 72% of the heat-related deaths in the 1995 Chicago heat wave (Whitman *et al.*, 1997). The elderly are also more likely to have pre-existing medical conditions, including cardiovascular and respiratory illnesses, which may put them at greater risk of exacerbated illness by climate-related events or conditions.

An urban heat island (UHI) is generated in rapidly urbanizing areas which is significantly warmer than its surrounding rural areas (Heidorn, 2009). Urbanization negatively impacts the environment mainly by the production of pollution, the modification of the physical and chemical properties of the atmosphere, and the covering of the soil surface. Considered to be a cumulative effect of all these impacts is the UHI, defined as the rise in temperature of any man-made area, resulting in a well-defined, distinct "warm island" among the "cool sea" represented by the lower temperature of the area's nearby natural landscape.UHIs have the potential to directly influence the health and welfare of urban residents. As UHIs are characterized by increased temperature, they can potentially increase the magnitude and duration of heat waves within cities. Research has found that the mortality rate during a heat wave increases exponentially with the maximum temperature (Buechley *et al.,* 1972), an effect that is exacerbated by the UHI. Climate change impacts on the Urban Heat Island (UHI) effect depends upon the geographic location of a specific city, its urban morphology (i.e. landscape and built-up characteristics), and areal extent (i.e., overall spatial "footprint"). Overall, climate change is likely to impact the UHI effect as urban areas grow and expands, as the UHI intensifies and increases, there is a subsequent impact as in deterioration of air quality. Moreover, the UHI has an impact on local meteorological conditions by forcing rainfall production either over, or downwind, of cities (Davis *et al.,* 2003). As the UHI effect intensifies, there will be a higher probability for urban-induced rainfall production (dependent upon geographic location) with a subsequent increase in urban runoff and flash flooding, exacerbation and intensification of the UHI would have impacts on human health: increased incidence of heat stress ; - impact on respiratory illnesses such as asthma due to increases in particulate matter caused by deterioration in air quality as well as increased pollen production because of earlier pollen production from vegetation in response to warmer overall temperatures (Lo and Quattrochi, 2003; Brazel and Quattrochi, 2006; Ridd, 2006 and Stone, 2006).

The rapid growing population and economic development is leading to a number of environmental issues in India because of the uncontrolled growth of urbanization and industrialization, expansion and massive intensification of agriculture, and the destruction of forests. Environmental issues in India include various natural hazards, particularly cyclones and annual monsoon floods, population growth, increasing individual consumption, industrialization, infrastructural development, poor agricultural practices, and resource maldistribution have led to substantial human transformation of India's natural environment. A number of studies have shown that air and water pollution are taking a heavy toll of human life, particularly, in the developing countries through ill-health and premature mortality. In an Indo-US joint workshop, on September 05, 2008 at Chandigarh, Prof S K Jindal said it has been globally recognised that environmental factors, have important links with infectious as well as non-infectious diseases of both acute and chronic nature. "The WHO estimates that 24 per cent of global disease burden and 23 per cent of all deaths can be attributed to environmental factors. The burden is more on the developing than the developed countries." He said: "In developing countries, an estimated 42 per cent of acute lower respiratory infections are caused by environmental factors."The major burden of these hazards is borne by the lungs. Bronchial Asthma and other allergies; chronic obstructive lung disease, respiratory infections including tuberculosis and occupational lung diseases are some of the common problems with a strong environmental risk which, account for a large disease burden all over the world, including in India.

Asthma is a multifactorial disease in which genetic susceptibilities influence responses to environmental exposures. Exposure to outdoor air pollution has been widely studied as a potential risk factor for asthma, and it is generally well established that short-term increases can exacerbate respiratory symptoms in children with asthma (Gilmour *et al.,* 2006; Thurston and Bates, 2003 and Trasande and Thurston, 2005). Ozone, particulate matter< 10 and < 2.5 μm in aerodynamic diameter (PM_{10} and $PM_{2.5}$), and nitrogen dioxide are the pollutants linked most consistently with exacerbation of asthma symptoms. Although long-term exposures toO_3, PM_{10}, and NO_2 have been associated with chronic respiratory impairments such as reduced lung function and growth, bronchitis, and chronic cough, evidence for the impact of air pollution on asthma incidence is less conclusive. Recently, focus has turned to respiratory effects caused by exposure to specific motor vehicle exhaust components such as polycyclic aromatic hydrocarbons adsorbed to particles from diesel engines and ultrafine particles (< 0.1 μm in aerodynamic diameter), which are able to penetrate cellular targets in the lung and enter systemic circulation (Künzli *et al.,* 2003; Li *et al.,* 2000 and Pandya *et al.,* 2002). Various measures of traffic exhaust exposure have been associated with adverse respiratory outcomes, including reduced lung function and growth; asthma hospitalizations; and prevalence of asthma, wheeze, bronchitis, and allergic rhinitis (English *et al.,* 1999; Gauderman *et al.,* 2005; 2007; Kim *et al.,* 2004 and McConnell *et al.,* 2006).Extensive studies to gauge the effects of environmental factors on the human health. India is predicted to become the world's most populous nation by the year 2050. Industrialization and urban growth are now occurring at an unprecedented rate in this previously agrarian society (Chowgule, *et al.,* 1998). Both prevalence and mortality from asthma appear to have increased in many parts of the world during a time when better asthma medications have been available to more patients suffering from asthma (Alderson, 1987).

India is a vast country with immense geographical and environmental diversities which affects the incidence and prevalence of chronic diseases. The vast economical, racial, religious and socio-political differences not only affect the prevalence but also the approach to management of chronic health problems. It is an enormously difficult and costly proposition to collect natural statistics on diagnosis and management of common diseases. It requires co-ordination and co-operation between several centers spread across the country. On the other hand an attempt to comprehend the multiple studies conducted by different investigators suffers from scientific drawbacks, the principle being a lack of uniformity in definition of diseases, methodology used for the study and analysis of data (Jindal, 2010).

Gujarat has established itself as a leader in various industrial sectors and occupies a prominent niche in progressive industrial development of the country. It is a second most industrialzed state in the country, most of the industrial growth is concentrated in the so called "Golden Corridor" that extends from Vapi in the south to Mehsana in the north. Monitoring of various industrial units conducted by Gujarat pollution control board (GPCB) shows stack emissions of SO_2, SPM and NH_3 exceeding acceptable limits, indicating inadequate air pollution control. Occupational health condition is another important concern. Ironically, there has been no systematic effort either to monitor the environment or to document its impact on health conditions. Despite setting up of the Gujarat Pollution Control Board (GPCB) and Gujarat Ecology Commission (GEC) the degradation and deterioration of the states' environmental resources have been on the rise. Gujarat is India's 3rd most polluted state. (De, 2007c). Vadodara enjoys a special place in the state of Gujarat. Vadodara (Baroda) is one of the mega cities of the state and the financial and commercial centre as well as a major industrial port. It is the state's most rapidly growing mega-city, with a projected population of 15 million in the year 2000. The city gains over 250,000 rural-to-urban emigrants annually. Vadodara lies on a narrow peninsula running north to south, connected to the mainland at the northern tip, constricting the geographic spread of its growing population. Situated at approximately 19 8 north latitude, the coastal city has the warm moist climate of a tropical savanna. Sulfur reductions in fossil fuels in recent years have helped reduce ambient sulfur dioxide levels, but the increasing density of motor vehicles contributes to rising concentrations of total suspended particulate. In the last few years the topography of the state has changed because of large-scale development works—laying of canals and railway tracks, construction of new colonies. The flash floods, we believe, were caused by changes in the topography. Vadodara city was once known as the City of Gardens. The growing urbanization and the demand for more housing and transportation have led to a decline in urban greens. The environment of a city is a critical determinant of the health of its inhabitants and consequently productivity. The problem of environmental pollution in the city has become a matter of concern in recent decades due to population explosion, industrialization, urbanization and increase in transportation. The pollution level in the city is determined by the air quality. Industries are considered as the triggering agents for urban environmental degradation, vehicular traffic accounts for nearly 20% of air pollution of the city (De, 2007c). Preliminary survey conducted in the city of Vadodara has confirmed the emerging health problems related to respiratory system. However, their main objective was restricted to the presence of the microorganisms suspended in air samples and its relation to the prevalence of the respiratory disease.

Meteorology is one of the prime factors responsible for global warming. Meteorological conditions are changing rapidly in atmosphere, thereby altering the whole system (Rao and Rao, 1999; Katsouyanni*et al.,* 1993; Samet*et al.,* 1998; O'Neil, Zanobetti& Schwartz, 2003). These changes cannot be attributed to just one of the factor, but it is a combined activity of all the factors. This shows that there is definitely interdependence among these factors, as a result of which if one factor is disturbed the other is also affected. There is hardly any data available for Vadodara city, bearing few sporadic reports conducted by GPCB, GEC and CEPT. Hence the present study is an attempt to understand the relationship between the environmental factors with special reference to existing meteorological conditions in Vadodara city and further to have an insight whether there exists any interdependence between the prevalence of the respiratory illness with particular reference to the asthma visits in Vadodara city. We have made an attempt to find out the link between the environment and analyzing existing asthma condition in Vadodara city. It is possible that combinations of meteorological factors as well as air pollutants may have greater effects on airway function than exposure to a single factor, although there is little evidence to support this.

Our first aim was to find the baseline trend and correlation between air pollution and meteorological parameters for Vadodara city for 2005 to 2007 (Chapter 1). Here, to understand the inter-relationship of the meteorological parameters and pollutions, 8 meteorological parameters viz., Height Of Lowest Layer, Cloud Cover, Maximum Temperature, Minimum Temperature, Wind speed, Rainfall, Relative Humidity and Vapor Pressure along with 3 pollutants viz., SO_2, NO_x and RSPM were considered for the study. Considering the fact, these 11 study parameters were then applied on SPSS 12.0, software termed as Statistical Package for Social Sciences version 12.0. It is through this package that receptor modeling is performed and the extent of interdependence among these 11 parameters and the trend of interdependence for last three years were analyzed. These parameters were then also assessed using shaft diagrams. Shaft diagrams are described as a mode of representing the ensemble data for huge period of time which otherwise may be very difficult to represent in a single diagram. Characteristic legends are used for the purpose and each of them in itself represents the character through visual anomalies. After identifying the correlation between the parameters, area of impact was to be found. This was made possible with the help of wind rose diagrams and the ISCST3 models. A wind rose is defined as "an illustrative way of presenting the wind data used by meteorologists to give a glimpse of how wind speed and direction are typically distributed at a particular site. It is drawn by polar coordinate system of gridding, where the frequency of winds over a time period are plotted by wind direction, with designated color bands showing wind speed ranges. The direction of the rose with the longest spoke depicts the wind direction with the greatest frequency in that particular direction". Comparisons of the trajectory analysis and the regime analysis with the data from the wind rose evaluations can be used to find significant microscale or synoptic scale meteorological anomalies that lead to some identifiable increases. Hourly wind speed and wind direction data was implied on the Lakes Environmental WR Plot Software to get the wind rose diagrams.

ISCST3 (Industrial Source Complex Short Term) is a steady-state Gaussian plume model which is used to assess pollutant concentrations. The regulatory default model option in ISCST3 can be selected for urban-wide applications (U.S. EPA, 1995b). The ISCST3 model computes with hourly concentration for each receptor. The averaging period selected is based on the intended use. Annual average air concentrations are generally needed for use in chronic (long-term) exposure studies. Shorter term ambient concentrations are usually needed for determining acute exposure. It requires the coordinates of the specified receptors, for which locations should be selected based on a case-to-case determination. The word isopleth (meaning 'quantity') is used for contour lines that depict a variable which cannot be measured at a point, but which instead must be calculated from data collected over an area. Hourly Wind speed, Wind direction, Temperature, Stability and Urban Rural mixing height data was used in ISCST3 models which were then mapped using SURFER. The observations were made to study the annual as well as the seasonal trend. It was observed that annual and seasonal variations of the conditions favorable to high pollution level and the definition of an area's micro climate in terms of air pollution is strongly supported. It can be established that such statistical analysis will help in predicting the air quality for pollutants in terms of meteorology. The analysis and results obtained from the present study is not only important for interaction of meteorological and pollutants, but also for urban planners and decision makers.

With the aim of finding the impact of such interactions on the urban population our next aim was to evaluate the risk of respiratory illness in the community with special reference to asthma (Chapter 2). **Asthma** is considered a multi-factorial disease with different phenotypes, affecting an estimated 300 million people worldwide (WHO, 2008).Since the pathogenesis of asthma is not fully understood most definitions of asthma are based on practical consequences. The Global Initiative for Asthma (GINA) has defined asthma as:"A chronic inflammation disorder of the airways in which many cells and cellular elements play a role. The chronic inflammation is associated with airway hyper responsiveness that leads to recurrent episodes of wheezing, breathlessness, chest tightness, and coughing, particularly at night or in the early morning. These episodes are usually associated with widespread, but variable, airflow obstruction within the lung that is often reversible either spontaneously or with treatment".

Questionnaire being the most preferred approach for identifying the individuals with Respiratory Illness in the city, the questionnaire history of the symptoms which is non-specific and is influenced by the frequency of other disease was chosen for the present studies. A standardized and validated study-questionnaire in consultation with the chest physician was made and it was also translated into local language.

The questionnaire used in the study had been aimed at collecting information on the respiratory symptoms and for establishing the prevalence of asthma, COPD and Rhinitis. As far as the questionnaire administration was concerned, random sampling was done for a population of 1000 of which only 792 responded correctly as required in the questionnaire. Further, the specific criteria of age, sex, education and occupation were taken into consideration. The age groups were broadly classified as 1-20 years; 21 to 40; 41 to 60; and 61 and above. The survey was done in 2008 and conducted over approximately 12 months.

For purpose of distribution analysis, descriptive parameters such as the means, standard deviation and percentage were used. Gender and age were used to create the subgroups for the entire study population. Prevalence of the asthma, rhinitis and COPD and individual respiratory symptoms in the identified groups were calculated in percentages as the number of subjects categorized as having asthma, rhinitis of COPD divided by the total number of subjects.. Out of the identified patients for total respiratory illness in the city, it was observed that in males the prevalence of COPD was 38%, Rhinitis 35% and Asthma 27% respectively. In case of females, however it was found to be a reverse trend where it was 36% Asthma, 35% COPD and 29% Rhinitis respectively. Out of all the three illness it was found that prevalence of rhinitis was higher in the age group of 1 – 20 years (42% in Females and 40% in Males), in age group 21 – 40 years prevalence of Asthma was higher in females (29%) and Rhinitis was higher in males (37%), in age group 41 – 60 years, prevalence of Asthma was higher in both males (35%) and Females (42%). For the age group 61 and above it was found that occurrence of Asthma again was higher in both males (27%) and females (19%).

Having known the past trend for the interaction between meteorological parameters and pollutants and the occurrence ratio of asthma in the city, our next aim was to find the association of meteorological variables and pollutants with the incidence of respiratory illness in relation with the medical sale in vadodara (Chapter 3).

Along with 8 meteorological parameters and 3 Pollutants, sale of 7 Respiratory medicines (i.e B. Inhalant Preparations, B. Inhalers, Inhaler Devices, B. Liquids, B. Injecta, B. Solids and B. Others)were considered in this study, the data was obtained from ORG department for year 2005 to 2010.These 18 parameters were then applied on SPSS 12.0 and the trend of interdependence for last five years was analyzed. In this study, increase in the medical sale was found dependent on distinct meteorological factors as well as pollutants and that each factor was acting as trigger for the increase in the specific medical sale proving to be the direct link between the triggering factors and respiratory illness. On detailed analysis it was found that wind speed, relative humidity, vapor pressure, cloud cover and RSPM had a greater influence with the sale of medicine and occurrence of the respiratory illness.

With the preview of having the meteorological factors responsible for the asthma exacerbations in the city, it was then decided to find the season and age specific trend of the exacerbation. Hence, our next aim was to find the correlation between asthma exacerbation with respect to alteration in lung function capacity and environmental triggers (Chapter 4). Pulmonary function tests are a group of tests that measure how well the lungs take in and release air and how well they move gases such as oxygen from the atmosphere into the body's circulation (Pellegrino *et al.*, 2005).A spirometer is one such device used to measure lung function. It is a powerful tool that can be used to detect, follow, and manage patients with lung disorders. The use of spirometry helps in detecting cases at an early stage when intervention may prevent further progression of the disease. Spirometric tests are performed on a large scale with different objectives for example, it gives additional information to help establish a clinical diagnosis in a patient and assess the prognosis in a patient. It is used in diagnosing asthma or to periodically re-assess how the asthma treatment is effective. The clinical significance of spirometry in disease was recognized more than sixty years ago, but in the last decade little attention has been devoted to its practical application. Vital capacity is the maximum amount of air that can be inhaled or exhaled from the lung. Forced Vital capacity is defined as the amount of air which can be forcibly exhaled from the lungs after taking the deepest breath possible.FEV1 is the maximal amount of air that an individual can forcefully exhale in one second. It is then converted to a percentage of normal. FEV1 is a marker for the degree of obstruction with asthma (Scott *et al.*, 2003):

* FEV1 greater than 80% of predicted= normal
* FEV1 60% to 79% of predicted = Mild obstruction
* FEV1 40% to 59% of predicted = Moderate obstruction
* FEV1 less than 40% of predicted = Severe obstruction

Normally FEV1 = 70-80% of the FVC. Airflow obstruction is diagnosed if FEV1 is <65% of the FVC. Patients with obstructive patterns are more likely to respond to bronchodilator therapy. The FEV1 can then be used to assess the response. It is also used to diagnose asthma (15-20%

variability in FEV1), to assess the severity wherein if the FVC declines, it is due to air trapping indicating severe asthma. FEV1 and FVC are also useful to monitor the condition and response to therapy (Masson *et al.,* 2005). It is hence generally recommended by the chest physicians that the FEV1 is measured seasonally. Peak expiratory flow varies with age and gender (Stanojevic *et al.,* 2008).

The correlation between severe asthma attacks and weather conditions such as thunderstorms has been known for some time. However, the effect of local weather on the measured values of lung function on a daily basis has not been investigated (Cobern *et al.,* 1995). Hence, in the present study an attempt is made to find out the correlation between the lung functions and environmental factors. Once the correlation has been documented, our next aim was to identify the area in which the pollutant precipitations have occurred and further establishing the direct correlation with the occurrence of asthma for Vadodara city

Over the period of four years (2007 – 2010) the total numbers of the recorded patient's visits were 5202, of which 3171 were males and 2031 were females. Out of the total 3171 males 17.5% were reported to be asthmatics. On the other hand of the documented 2031 females 42% were found to be asthmatics, indicating the dominance of the female gender suffering from asthma in Vadodara city. The onset of asthma dominance was observed in age group of 31 plus in males as well as females and persisted till the age group of 60. Irrespective of the gender of all the age groups the maximum occurrence of the asthmatics documented were belonging to the age group of 41-50.Thenext objective of the present study was to assess the association between air pollution, meteorological conditions in a panel of adult group of female patients suffering from asthma, living inVadodara city. To achieve the precise objective, the entire study further was divided into two parts (Part A& B). Study in Part A was to find the correlation between the lung function values and environmental factors whereas the study in part B was to find the spatio-temporal distribution of asthma patients in Vadodara city.

Results in Part A study depicted that lung functions had shown a remarkable association with the meteorological factors and pollutants. However, the sensitivity of each triggering factor varied seasonally with each environmental factor and showed significant response to all the recorded lung functions. When seasonal lung functions were monitored of the selected asthma patients, there was a distinct correlation observed. Here, all the three lung functions expressed the response differently in the summer season. Also, individual seasonal analysis showed maximum participation of the triggers in the summer season, of all the years studied, 2008 showed the significant alterations in the lung functions, **FVC, FEV1** and **PEF** showing a significant positive correlation with **RH** and**VP**.Monsoon and winter were not showing strong correlation compared to summer inspite of having the maximum asthma exacerbations in winters (42%) followed by monsoon (33%). Having the summer asthma exacerbations showing positive significant participation with all environmental factors, our next aim was to find age wise summer correlation with the asthma exacerbation within 41 to 50 years in females. It was found that females at the age of 42, 43, 45, 46 and 48 were mainly affected by asthma exacerbations in summer.

Results in Part B, depicted that seasonal differences occurred between spatio-temporal plots considered in different seasons. In this study our aim was to look into the pollution pocket as well as the wind rose pattern in Vadodara city. The frequencies of specific wind directions as well as the wind speeds varied from year to year due to the frequency of weather patterns that can affect an area. There are, however, some important differences that can be readily observed in the wind roses. In summer season (2007 – 2010) it was found that majority of females were residing in and around the pollution pockets which was not the case in monsoon and winter season. The alterations in the lung functions were observed in the monsoon and winter season also but it was not found to be correlating with the identified pollution pockets for the respective season, probably suggesting that the monsoon and winter season exacerbations were not due to the environmental triggers but theymay be due to the respiratory viral illness or genetic inheritance.

Having known that during summer season environmental triggers were showing maximum correlation, individual lung functions also exhibited differential correlation with environment factors with respect to FVC, FEV1 and PEF. PEF is considered as a valuable marker of bronchial asthma as well as an indicator of poor prognosis (Bagg and Hughes, 1980) and hence considering the same, peak flow meters were supplied to the selected patients of the age group 41 – 50 years to record the PEF values and monitor the asthma exacerbations (Chapter 5).

Self-management plans based on either peak flow or symptoms are of similar efficacy (Turner *et al.,* 1998), so the method of self-monitoring should be tailored to patient skill levels, preferences, and resources. Fundamental to the success of guided self-management is the ability of the patient to recognize deterioration in asthma control. Recommendations for asthma care needs to be adapted to local conditions, resources and services. The patient must be taught to assess asthma severity by interpreting key symptoms and performing measurements of peak flow (Thoonen *et al.*, 2003 and Reddel and Barnes, 1996). Simple advice to seek medical attention if there are any nighttime symptoms, especially nocturnal wakening, or if symptoms do not respond to increased use of inhaled 2-agonist therapy may be the most important message to convey (Windom *et al.,* 1990 and Spitzer *et al.,* 1992). Domiciliary measurements of peak flow, with values interpreted as a percentage of normal predicted or previous best achieved recordings, are used as an objective assessment of the degree of airflow obstruction. Objective measurements are important because studies suggest that many patients are unable to reliably detect changes in their lung function–that is, they cannot correlate their subjective perception of asthma with measurements of lung function such as peak expiratory flow (Kendrick *et al.,* 1993). This diminished perception of lung function changes may correlate with the severity of the underlying asthma (Bijl-Hofland *et al.,* 1999) and is associated with an increased risk of death (Barnes, 1994), so peak flow monitoring is particularly important in adults with severe asthma.

We provided to all patients a written asthma action plan that included daily management and recognizing and handling changes in PEF measures. A written asthma action plan was particularly recommended for patients who belonged to age group 41 to 50 years in females.

Total forty six patients were selected for asthma management strategy out of which twenty one subjects had dropped out of the study for various reasons and were considered as non-attenders, or group NA. Rest Twenty-five patients with summer asthma exacerbations were enrolled for the management programme. They were the same group of patients who had shown the correlation with the specific environment. These remaining 25patients took part in an asthma education program including an action plan based on PEF monitoring and were asked to measure their PEF morning and evening; they were given a peak flow meter and a diary card. Patients involved in the study were then taken for the individualized asthma management strategy which included an hour session wherein they were instructed to adjust the treatment according to their PEF values. At each follow-up visit, reinforcement regarding the usefulness of PEF monitoring was given. The specialized physician also reviewed the diary card to check whether the patient had increased his asthma medication when PEF dropped.

During a 1-year randomized prospective study, participants were asked to measure morning and evening PEF throughout the year. The best of the three consecutive measurements of PEF values had to be recorded in their diaries. They all participated in an individualized asthma education program that covered the following issues of asthma triggers, criteria of good asthma control, usefulness of PEF monitoring, and management of asthma exacerbations according to PEF values. A patient's best peak expiratory flow was determined by use of the peak flow meter twice daily when the patient's lung function was at its best. From that baseline, the patient's 'zones' were then determined as Green Zone - 80 - 100 % of patient's personal best PEF, Yellow Zone - 50 - 80 % of patient's personal best PEF and Red Zone - less than 50 % of patient's personal best PEF. Once the individual patient's zones were defined, they were instructed on actions to take for each zone. PEF measures could also be used to help diagnose asthma, assess the influence of environmental factors on asthma, and document changes in asthma therapy. Along with the peak flow meters we provided the selected group of patients with a written asthma action plan that included instructions for daily management and recognizing; handling worsening of asthma along with changes in PEF measures. They were appraised on how to monitor signs and symptoms so they can recognize early signs of deterioration and take appropriate action, particularly since many fatal asthma exacerbations occur out of hospital (Krishnan *et al.,* 2006). They were taught by the physicians how to adjust their medications early in an exacerbation (Kelly *et al.,* 2002b) and when to call for further help or seek medical care. They were asked to opt for medical help earlier if the exacerbation was severe; treatment did not give rapid, sustained improvement; or there was further deterioration. In our study, even though patients were instructed in why to use peak flow meters and how to use them properly, their compliance with monitoring was not optimal. Throughout the study period, the average compliance of the patients with PEF record maintenance decreased from 71% of measurements at 1st month, to 58% at 6th month and finally to 30% at 12th month. When compared with a usual care group, the experimental group showed improvement in compliance and reductions in asthma exacerbations and visits to chest physicians. At the end of 1 year, 26% of the patients achieved total control on their asthma exacerbations (i.e., the absence of any sign or symptom of asthma), and 52% had achieved well controlled asthma.

From the present studies one can summarize that there is an increasing trend in the asthmatics and that there is substantial number of the patients having the direct correlation with the environmental factors. Respiratory diseases constitute about 15 % of the total disease burden in India. The common respiratory diseases which have a proven association with air pollution are tuberculosis pneumonia, COPD, asthma, lung cancer and pneumoconiosis. There is a need for further better understanding the environmental risks to human health in developing countries. Medical specialties such as pulmonary medicine are minimally engaged in research and training related to the environmental risks of respiratory disease despite of the recognized importance of acute and chronic respiratory diseases is one of the major global burdens in the country. However, due to the limitation of the time the ethnicity, socio-economic status, allergy, pollens triggering activity, stress, impact of vehicular emissions, industrial emissions, indoor (domestic) and outdoor pollution etc could not be studied but will be open for our future study prospects.