AIR QUALITY ANALYSIS OF SHIMLA CITY

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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to

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CERTIFICATE

This is to certify that the work which is being presented in the project title **"AIR QUALITY ANALYSIS OF SHIMLA CITY"** in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by Harshit Thakur (121689) during a period from **JULY 2015 to JUNE 2016** under the supervision of **Dr.Rajiv Ganguly** Associate Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

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ABSTRACT

Now a days increasing air pollution is becoming a huge problem. Its control through its determination and analysis has become necessary in major cities . This project aims at doing a detailed analysis on shimla city pollution and its air pollutants by calculating air quality index and plotting graph with respect to its time details and amount of pollutants released. Shimla is a growing town and attractions of tourism as well as state headquarters , so different vehicles and industrial work are on hike in the past decade.

Air quality indices are used for local and regional air quality management in many metro cities of the world. In the present study, air quality indices have been calculated using the US Environmental Protection Agency procedure to assess the status of ambient air quality near busy traffic intersections in shimla, India

Meteorological conditions play a crucial role in ambient air pollution by affecting both directly and indirectly the emissions, transport, formation, and deposition of air pollutants. In this paper, the effects of meteorological conditions on local air quality pollutants are quantitatively assessed by determining the relationships between concentrations of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2), suspended particulate matter (SPM), respirable suspended particulate matter (RSPM) with meteorological parameters such as minimum temperature (Tm), maximum temperature (TM), average temperature (Tavg), precipitation (P) and relative humidity (R.H) on monthly basis. Moreover Shimla also includes ecologically sensitive area, but a little is known about air pollutants and meteorological parameters for ecologically sensitive area.

This study includes detailed statistical analysis for both residential and ecologically sensitive area, using the multi-linear regression technique to develop a relationship and predicting the ambient air quality pollutants (i.e SPM, RSPM, SO_2 and NO_2) in conjunctions with meteorological parameters (i.e Tm, TM, Tavg, P, R.H) of the Shimla city

Keywords: Air Pollution, SO_2, NO_2, SPM, RSPM, AIR QUALITY INDEX, Shimla

Chapter -1

INTRODUCTION

1.1 Background

As the impact of air pollutants on human health through ambient air address much attention in recent years, the air quality forecasting in terms of air pollution parameters becomes an important topic in environmental science. The Air Quality Index (AQI) can be estimated through a formula, based on comprehensive assessment of concentration of air pollutants, which can be used by government agencies to characterize the status of air quality at a given location. The present study aims to develop forecasting model for predicting daily AQI, which can be used as a basis of decision making processes. Firstly, the AQI has been estimated through a method used by US Environmental Protection Agency (USEPA) for different criteria pollutants as Respirable Suspended Particulate Matter (RSPM), Sulfur dioxide (SO2), Nitrogen dioxide (NO2) and Suspended Particulate Matter (SPM). However, the sub-index and breakpoint concentrations in the formula are made according to Indian National Ambient Air Quality Standard.

Activities for development like manufacture, transport, construction is a big threat on natural resources along with huge production of harmful substance and large amount of waste which is leading to a major factor of air pollution, global warming and acid rain. By world health organization, environmental pollution is "the substance put into environment by the activity of humans into concentration sufficient to cause harmful effect to the health

As for the health impact of air pollutants, AQI is an important indicator for general public to understand easily how bad or good the air quality is for their health and to assist in data interpretation for decision making processes related to pollution mitigation measures and environmental management. Basically, the AQI is defined as an index or rating scale for reporting daily combined effect of ambient air pollutants recorded in the monitoring sites.

Rapid industrialization & urbanization has resulted in the emergence of industrial centers that results in increase in pollution level of the air .The air we breathe is a mixture of gases and small solid & liquid particles. In India, pollution has become a great topic of debate at all levels and especially the air pollution because of the enhanced anthropogenic activities Among the harmful chemical compounds, of fossils fuels burning puts into the atmosphere, are carbon dioxide (CO_2), Carbon monoxide (CO), Nitrogen oxide (NO_X), Sulfur Dioxide (SO_2) and tiny solid particles –including lead from gasoline additive called particulate. Some substances come from natural sources while others are caused by human activities. Air pollution occurs when the air contains substances in quantities that could harm the comfort or health of humans and animals, or could damage plants and materials. These substances are called air pollutants and can be either particles, liquids or gaseous in nature . Particulate matter and gaseous emissions of pollutant emission from industries and auto exhausts are responsible for rising discomfort, increasing airway diseases and deterioration of artistic and cultural patrimony in urban centers.As many cities around the world become more congested, concerns increase over the level of urban air pollution being generated and in particular its impact on localized human health effects such as asthma or bronchitis. The more this relationship is understood, the better chance there is of controlling and ultimately minimizing such effects. In the majority of the developed world, legislation has already been introduced to the extent that local authorities are required by law to conduct regular Local Air Quality Reviews of key urban pollutants

1.2 CLASSSIFICATION OF AIR POLLUTANTS

The air pollutants can be classified as primary or secondary pollutants. The primary air pollutants are harmful chemicals which directly enter the air due to natural events of human activities. Secondary air pollutant is a harmful chemical produced in the air due to chemical reaction between two or more components. That is primary pollutant combines with some component of the atmosphere to produce a secondary pollutant (Naik, S., 2005)[17]. Particulate matter formed from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution; the word "smog" is a portmanteau of smoke and fog. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulfur dioxide. Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by sunlight to form secondary pollutants that also combine with the primary emissions to form photochemical smog. There are many types of air pollutants such as nitrogen oxides, carbon monoxides, and organic compounds that can evaporate and enter the atmosphere. The air pollutants selected in the present study are:

(i) Sulfur dioxide (SO_2) (ii) Nitrogen dioxide (NO_2) (iii) Total Suspended Particle (TSP) (iv) Particle Less Than 10 micron (PM_{10})

(i) Sulfur dioxide (SO_2): It is a colourless gas with a pungent and suffocating odour. The gas is produced by the combustion of fossil fuels (Naik S., 2005)[17]. Sources include industrial activities such as flaring at oil and gas facilities and diesel power generation, commercial and home heating and vehicle emissions. The amount of SO_2 emitted is directly related to the sulfur content of the fuel (Air Quality Monitoring Network, 2008).

(ii) Nitrogen Dioxides (NO_2): The Nitrogen oxide represents the sum of the various nitrogen gases found in the air, of which Nitric Oxide (NO) and Nitrogen Dioxide (NO_2) are the dominant forms. The emission sources are varied but tend to result from high temperature combustion of fuel for industrial activities, commercial and residential heating, and vehicle use. Forest fires can be a large natural source of NO_2 (Air Quality Monitoring Network, 2008).

(iii) Total suspended particulate (TSP): TSP refers to particles ranging in size from the smallest to a generally accepted upper limit of 50-100 microns in diameter. TSP is dominated by the larger sized particles commonly referred to as “dust” and is associated with aesthetic and environmental impacts such as soiling of materials or smothering of vegetation (Air Quality Monitoring Network, 2008). The entire domain of particulate matter is known as Total Suspended Particulate, TSP (IPCC, 2001). This includes all airborne solid and liquid particles, except pure water, ranging in size from approximately 0.005mm to 100mm in diameter (Balaceanu C. et al., 2004).

(iv) PM_{10} : Particulate matter is a ubiquitous pollutant, reflecting the fact that it has both natural and anthropogenic sources. Natural sources of primary PM include windblown soil and mineral particles, volcanic dust, sea salt spray, biological material such as pollen, spores and bacteria and debris from forest fires (National

Ambient Air Quality Objectives for Particulate matter, 1998). PM10 refers to particulate matter that is 10 μm or less in diameter.

1.3 Effect of air pollution

Air pollution is a basic problem in today‟s world. Exposure to ambient air pollution has been linked to a number of different health outcomes, starting from modest transient changes in the respiratory tract and impaired pulmonary function, continuing to restricted activity/reduced performance, emergency room visits and hospital admissions and to mortality. There is also increasing evidence for adverse effects of air pollution not only on the respiratory system, but also on the cardiovascular system (WHO, 2004). Physical damage functions relating health (mortality and morbidity) to air pollution levels have been estimated over a number of years in different countries). Although the net effect of pollutants on health is unclear. The major air pollutants discussed in the present study are sulfur dioxide, nitrogen oxides, ammonia, carbon monoxide, TSP and PM10.The harmful effects of these pollutants are discussed here in detail:

(i) Sulfur Dioxide (SO2): Elevated concentrations of SO2 can be indicated by an odor of „burning matches‟ and are associated with human health impacts, including respiratory (breathing) effects, especially asthma. Vegetation, especially lichens, can be very sensitive to SO2 at relatively low concentrations (Air Quality Monitoring Network, 2008)[3]. The gas irritates airways and eyes and is known to cause longer-term heart diseases, other cardiovascular ailments, and bronchitis. It also readily causes shortness of breath and coughing amongst asthma sufferers. SO2 is also a major contributor to acid rain, which damages the environment and upsets ecosystems (Chan Wai-Shin et al, 2007)

(ii) Nitrogen Dioxides (NO2): It causes severe respiratory problems, especially in children. When combined with water, it forms nitric acid and other toxic nitrates. NO2 is also a main component in the formation of ozone at the surface level. The gas irritates the lungs and has been known to lower the immune system. It may cause acidification and eutrophication harmful to health (mainly the respiratory system), materials, cultural artifacts, vegetation and crops (Sida, unknown). Elevated concentrations of NO2 can also affect visibility though creation of„reddish brown‟ hazes (Air Quality Monitoring Network, 2008) .

(iii) Total suspended particulate (TSP): TSP is associated with aesthetic and environmental impacts such as soiling of materials or smothering of vegetation (Air Quality Monitoring Network, 2008).It may pose the greatest threat to human health because, for the same mass, they absorb more toxic and carcinogenic compounds than larger particles and penetrate more easily deep into the lungs (Masitah Alias et al, 2007).

(iv) PM10 : The increases in particulate matter have been shown to cause small, reversible decrements in lung function in normal asymptomatic children, and in both adults and children who have some form of pre-existing respiratory condition, particularly asthma. These changes were often accompanied, especially in adults, by increases in symptoms such as chronic bronchitis or cough (National Ambient Air Quality Objectives For Particulate matter, 1998).

Coarse Particles (PM_{10})	**Fine Particles ($PM_{2.5}$)**	
What they are	smoke, dirt and dust from factories, farming, and roads mold, spores, and pollen	toxic organic compounds heavy metals
How they're made	crushing and grinding rocks and soil then blown by wind	driving automobiles burning plants (brush fires and forest fires or yard waste) smelting (purifying) and processing metals

Table 1.1 coarse and fine particle constituents

Chapter-2

Literature review

The rapid industrialization leading to urbanization, unplanned and excessive exploitation of natural resources have been causing pollution problems in cities and towns of developing countries. Man made and natural sources of emissions have polluted the air with toxic substances. The national average per capita SO_2 emission was 4.2 kg per person in 1990, which rose to 5 kg in 1995, an increase of almost 20% in 5 yr. In 1990, coal consumption contributed 64% of total SO_2 emissions in India, oil products 29%, biomass 4.5% and non-energy consumption 2.5% (Garg, A., et.al, 2001). Total SO_2 and NO_x emissions from India were 3542 and 2636 Gg respectively (1990) and 4638 and 3462 Gg (1995) growing at annual rate of around 5.5%. The sectoral composition of SO_2 emissions indicates a predominance of electric power generation sector (46%). Power and transport sector emissions equally dominate NOX emissions contributing nearly 30% each (Garg, A., et.al, 2001)[10]. The ambient air quality in Madurai City of South India was studied and it was found that the TPM concentration varied from 200 to 500 µg / cu-m, NO_x from 50 to 170 µg / cu-m and SO_2 from 10 to 25 µg / cu-m. The Ambient Air Quality of Jyotivihar, Orissa in terms of TSP, SO_2 and NO_x was studied during December–1994 to November–1995. The minimum and maximum values were 82.995 µg/cu-m and 182.7 µg/cu-m for TSP, 4.62 µg/cu-m and 25.74 µg/cu-m for SO_2 and 4.39 µg/cu-m and 16.89 µg/cu-m for NO_x (Naik S., 2005). A report showed that SPM concentrations in Shanghai, New Delhi, Mumbai, Guangzhou, Chongquin, Calcutta, Beijing and Bangkok exceeded WHO limits (90 µg/cu-m) by three, five, three, three, four, four, four and two times respectively . It also showed that PM_{10} exceeded the USEPA limit (50µg/cu-m) by several times in a number of cities, most notably by over four times in New Delhi and Calcutta. Data from Tokyo shows that TSP increased rapidly from 40µg/cu-m in the early 1980s to over 70µg/cu-m in the early 1990s; after that TSP has been decreasing or stagnating, but it is becoming an increasing challenge to contain TSP and NO_x (Air Pollution Control in the Transportation Sector, 2007. The Central Pollution Control Board monitors the quality of air at nine stations in Delhi. The latest data published before the field work commenced pertained to 1991(CPCB, 1992). The range of mean annual concentrations across these nine stations were: total suspended particulates (TSP) =255–643 µg/cu-m; nitrogen dioxide (NO_2) =24.2–61.7 µg/cu-m; sulfur dioxide (SO_2) =8.4–51.2 µg/cu-m. The overall mean level of RSP in this micro-environment was 390µg/cu-m. The average level of

PM10 as measured at nighttime indoors was found to be comparably very high F 900 µg/cu-m (Saksena et al, 2003). A recent study in middle-income homes of Delhi found PM10 levels to be as high as 170–810 µg/cu-m even in homes where there was no cooking or smoking activity (Kumar, 2001)[23]. A study for assessment and management of air quality was carried out in the Ib Valley area of the Ib Valley coalfield in Orissa state, India. The 24 h average concentrations of total suspended particulate (TSP), respirable particulate matter (PM10), sulfur dioxide (SO2) and oxides of nitrogen (NOx) were determined at regular intervals throughout one year at twelve monitoring stations in residential areas and six monitoring stations in mining/industrial areas. The 24 h average TSP and PM10 concentrations were124.6- 390.3 µg/cu-m and 25.9–119.9 µg/cu-m in residential areas, and were 146.3–845.2 µg/cu-m and 45.5–290.5 µg/cu-m in industrial areas. The rural-industrial site at Satna shows significant different from urban, urbanindustrial, rural, rural-remote and rural–urban influenced sites. With a minimum of one daily sample at each site, mean PM10 concentration at the rural-industrial Satna site varied from 65.5 to147.5 µg/cu-m, and from 205.0 to 320.3µg/cu-m at the urban-industrial Delhi site. With a minimum of one daily sample at each site, the mean TSP concentration at the rural-industrial Satna site varies from 283.9 to 678.0 µg/cu-m, while at the urban industrial Delhi site mean TSP concentration varies from 553.4 to 827.6 µg/cu-m. The maximum TSP concentration in Satna, 678.0 µg/cu-m, was on December 9, 2000. Maximum TSP concentration in Delhi, 827.6 µg/cu-m, occurred on October 23, 2000. Levels of TSP in Ashok Vihar, a residential area in Delhi, reached 10 times the permissible limit in October 2000 (Shandilya Kaushik. K. et al, 2007). The atmospheric concentrations of gaseous ammonia has been measured by Perrino et al. (2002) during spring of 2001 to spring of 2002 in an urban area of Rome, at many traffic sites and at an urban background sites. The results indicated that emissions from petrol–engine vehicles equipped with catalytic converters could be an important source of ammonia in urban areas. Whereas, in another study in south coast air basin, mobile sources were estimated to represent 18% of the NH 3 inventory (Chitjian et al., 2000). Burkhardt et al.(1998) measured atmospheric ammonia (NH3) concentrations over a period of two years near Edinburgh, Scotland and concluded that arithmetic mean of NH 3 concentrations was largest in spring and autumn. This study also confirmed that NH3 concentrations were influenced by local sources and background concentrations depending on the wind direction.

. The Air Quality Index (AQI) can be estimated through a formula, based on comprehensive assessment of concentration of air pollutants, which can be used by government agencies to characterize the status of air quality at a given location. The present study aims to develop forecasting model for predicting daily AQI, which can be used as a basis of decision making processes. There are primarily two steps involved in formulating an AQI: first the formation of sub–indices of each pollutant, second the aggregation (breakpoints) of sub indices. Breakpoint concentrations of each pollutant, used in calculation of AQI, are based on Indian NAAQS and results of epidemiological studies indicating the risk of adverse health effects of specific pollutants. It has been noticed that different breakpoint concentrations and different air quality standards have been reported in literature . In India, to reflect the status of air quality and its effects on human health, the range of index values has been designated as:

AQI VALUES	**Levels of health concern**	**colors**
AQI range	**AQI conditions**	**color**
0-50	**GOOD**	**GREEN**
51-100	**MODERATE**	**YELLOW**
101-150	**MODERATE UNHEALTHY**	**ORANGE**
151-200	**UNHEALTY**	**RED**
201-300	**VERY UNHEALTHY**	**PURPLE**
301-500	**HAZARDOUS**	**MAROON**

Table2.1 AQI values indicator

2.1 OVERVIEW OF THE CITY

The Himachal Pradesh State Pollution Control Board was constituted in the year 1974 under the provision of Water (Prevention and Control of Pollution) Act, 1974. Subsequently the implementation of the provision contained in Water (Prevention and Control of Pollution) Cess Act, 1977, Air (Prevention and Control of Pollution) Act, 1981 and Environmental Protection Act, 1986 in addition to Rules framed under these Acts were also entrusted to the State Board. The prime objective of all these Acts is maintaining, restoring and preserving the wholesomeness of quality of environment and prevention of hazards to human beings and terrestrial flora and fauna. Himachal Pradesh State Pollution Control Board is a nodal agency in the administrative structure of the State Government for planning, coordination, prevention & control of pollution and so also protection of environment in the framework of environmental regulations. The State Board has always endeavoured to strike a rational balance between economic growth and environmental preservation. In the pursuit of attaining the objectives enshrined in the environmental legislations the State Board has followed the principles of sustainable development. Continuous efforts are being made by the board to expand its activities to fulfill the demands of emerging environmental concerns, challenges and new statutes[Annual report2012-2013]

During a year Shimla has mean temperature of 17.57℃, which varies from minimum of 12.73℃ to maximum of 22.27℃; mean relative humidity of 64.428%. Studies undertaken elsewhere (such as,Jiang et al.,2004,2005; Sun et al., 2004; Leong and Laortanakul,2003) have indicated that both dynamic and physical properties of atmosphere play important roles in determining air pollutant concentration. Li et al. (2005) observed that diurnal variation of gaseous pollutant concentration is closely related to changes in atmospheric stability and mean kinetic energy in atmospheric boundary layer in Beijing area. In India generally, such investigations are very few in number and limited, in scope. This makes it difficult to assess the potential adverse effects of air emissions, and consequently limits development of effective air quality management strategies due to high degree of scientific uncertainties.

Through this particular section of this project, a study has been carried out in order to assess the role of meteorological conditions in determining the concentrations of pollutants and oxides of Nitrogen such as NO_2

Figure 2.11 map of study area SHIMLA

AMBIENT AIR QUALITY MONITORING: The monitoring of Ambient Air Quality was started in 1986-87 under the National Ambient Air Quality Monitoring Programme (NAMP) with the objective to find the current status of pollution and to study the trends as a result of increasing industrialization. The general objectives of the programme are: 1. To evaluate the general air quality conditions in the cities and to provide the basis for analyzing long term trends of pollution concentrations.

To provide the data for subsequent development of air quality standards and pollution prevention and control programme for the cities. The Respirable Suspended Particulate Matter (RSPM) is monitored with the help of Respirable Dust Sampler on the basis of three days per station per week for 24 hours at 10 Towns/Cities covering 20 nos. of locations in the State. The State Board has also initiated air quality monitoring stations at Dharamshala[Annual report2012-2013]

National ambient air quality standards (NAAQS) as notified in 18th November 2009 are given below:

S. No.	Pollutant	Time Weighted Average	Concentration in Ambient air		
			Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (Notified by Central Govt.)	Method of Measurement
1	Sulphur Dioxide	Annual*	50 µg/m³	20 µg/m³	-Improved West and Gaeke -Ultraviolet fluorescence
		24hours**	80 µg/m³	80 µg/m³	
2	Nitrogen Dioxide	Annual*	40 µg/m³	30 µg/m³	-Modified Jacob and Hochheiser (Na-Arsenite) -Chemiluminescence
		24hours**	80 µg/m³	80 µg/m³	
3	Particulate Matter (PM_{10}) (size less than 10 micron)	Annual*	60 µg/m³	60 µg/m³	-Gravimetric -TOEM -Beta attenuation
		24hours**	100 µg/m³	100 µg/m³	
4	Particulate Matter ($PM_{2.5}$) (size less than 2.5 micron)	Annual*	40 µg/m³	40 µg/m³	-Gravimetric -TOEM -Beta attenuation

Table 2.2

2.2 AMBIENT AIR QUALITY STATUS IN HIMACHAL PRADESH

Ambient air quality is being monitored in 10 towns/cities at Shimla, Parwanoo, Jassur, Paonta Sahib, Kala Amb, Baddi, Nalagarh, Sunder Nagar, Manali and Una under National Ambient Air Quality Monitoring Program. Air quality standards fixed for 24 hour average is 100 µg/m3 for RSPM and 80 µg/m3 for SO2 & CHAPTER –4 STATUS OF AMBIENT AIR, RIVER WATER QUALITY & VEHICULAR POLLUTION IN HIMACHAL PRADESH [Annual Report 2012-13] Page 9 NO2 and annual average standard is 60 µg/m3for RSPM, 50 µg/m3 for SO2 & 40 µg/m3 for NO2. The data collected of all the stations for the year 2012-13 scrutinized for the annual average and peak values for 20 locations and trends of annual average of SO2, NO2 and RSPM are shown below:

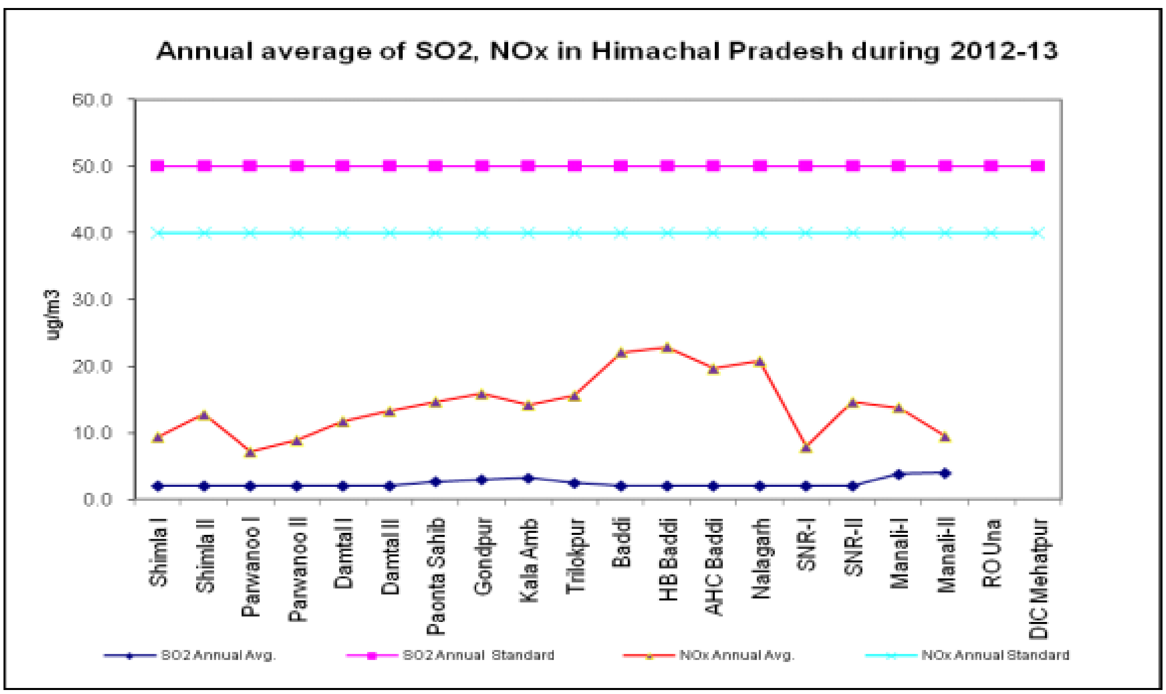


Figure 2.3

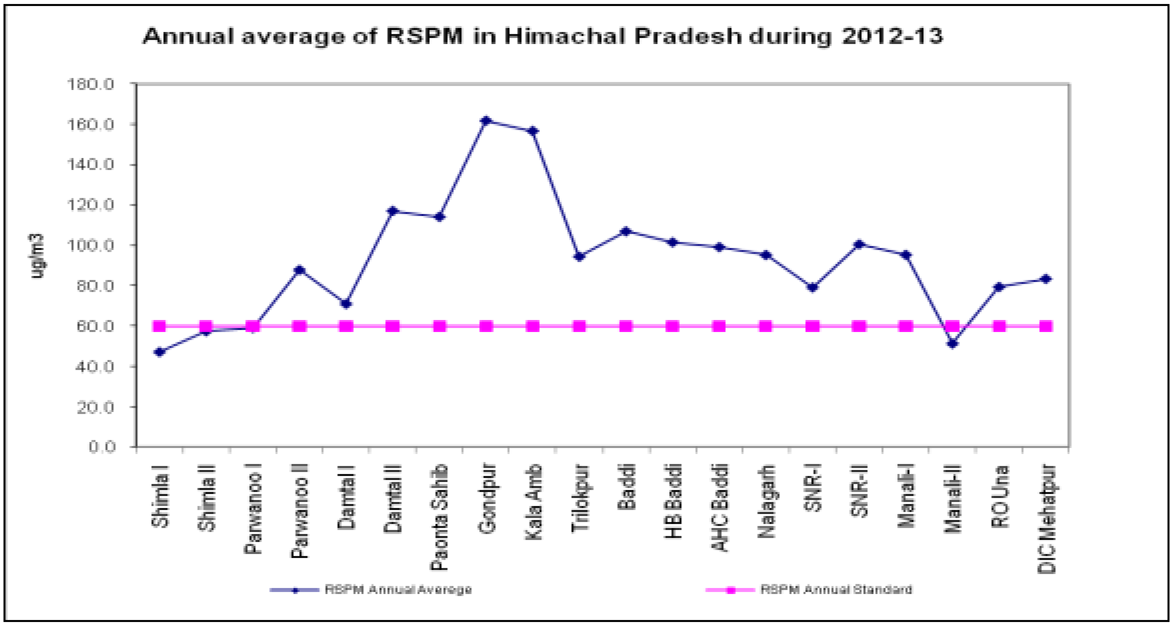


Figure 2.4

2.3 POLLUTION PREVENTION & CONTROL: Consequent to regular surveillance & monitoring activities, constant pressure is maintained on the polluting industries for operation and maintenance of the CHAPTER-5 POLLUTION CONTROL, SURVEILLANCE & MONITORING [Annual Report 2012-13] . During the year 110 new pollution control systems were got installed in the new industries to whom consents to operate were granted during the year. In addition to the three stages conventional treatment comprising of physico-chemical and biological treatment, State Board has also taken initiative to introduce tertiary level of treatment in the industrial units particularly those in Baddi-Barotiwala area. Improvements in the already existing control systems in respect of 111 industries were also got incorporated including those, which were ordered disconnection of power due to non-performance of the pollution control systems. In addition smooth functioning of the pollution control systems installed in the existing industries was ensured by exercising regular checks by the Regional Offices.

AIR POLLUTION CONTROL DEVICE

Source :[Annual Report 2012-13]   Figure 2.6

Air quality data used in this study are concentrations of SO_2, NO_2, SPM, RSPM measured at two long-term monitoring sites, Tekka Bench Ridge (Ecologically Sensitive) and Bustand Winter Field (Residential), located in Shimla, Himachal Pradesh.

CHAPTER-3

INPUT DATA AND ANALYSIS

3.1 METHODOLOGY

***Table 1**. Proposed sub-index and breakpoint pollutant concentrations for Indian-AQI*

Sl.No.	Index values	Descriptor	SO_2 (24-h avg.)	NO_2 (24-h avg.)	RSPM (24-h avg.)	SPM (24-h avg.)
1	0-100	Good [a]	0-80	0-80	0-100	0-200
2	101-200	Moderate [b]	81-367	81-180	101-150	201-260
3	201-300	Poor [c]	368-786	181-564	151-350	261-400
4	301-400	Very Poor [d]	787-1 572	565-1 272	351-420	401-800
5	401-500	Severe [e]	>1572	>1272	>420	>800

[a] *Good: Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people.*

[b] *Moderate: Members of sensitive groups may experience health effects.*

[c] *Poor: Members of sensitive groups may experience more serious health effects.*

[d] *Very poor: Triggers health alter, everyone may experience more serious health effects.*

[e] *Severe: Triggers health warnings of emergency conditions.*

Figure 3.0 AQI CALCULATIONS

Date	Name of the Monitoring Station	4 hourly Data Value of SO_2 6AM - 10AM	4 hourly Data Value of SO_2 10AM - 2PM	4 hourly Data Value of SO_2 2PM - 6PM	4 hourly Data Value of SO_2 6PM - 10PM	4 hourly Data Value of SO_2 10PM - 2AM	4 hourly Data Value of SO_2 2AM - 6AM	4 hourly Data Value of NOx 6AM - 10AM	4 hourly Data Value of NOx 10AM - 2PM	4 hourly Data Value of NOx 2PM - 6PM	4 hourly Data Value of NOx 6PM - 10PM	4 hourly Data Value of NOx 10PM - 2AM	4 hourly Data Value of NOx 2AM - 6AM	8 hourly Data of RSPM 6AM-2PM	8 hourly Data of RSPM 2PM-10PM	8 hourly Data of RSPM 10PM-6AM	So2	Nox	Pm10
03.01.2011	Tekka	4.1	5.3	2.0	5.8	2.0	2.0	4.5	4.5	4.5	4.5	4.5	4.5	19	39	12	3.5	4.5	23.3
05.01.2011	Tekka		2.0	2.0	2.0	4.9	6.3		4.5	4.5	4.5	4.5	4.5	44	12	3	3.4	4.5	19.5
07.01.2011	Tekka		2.0	2.0	2.0	2.0	2.0		9.1	11.4	4.5	4.5	4.5	32	104	45	2.0	6.8	60.3
10.01.2011	Tekka	2.0	2.0	2.0	4.4	6.3	7.8	4.5	4.5	4.5	4.5	4.5	4.5	22	69	25	4.1	4.5	38.7
12.01.2011	Tekka	2.0	2.0	4.4	2.0	5.3	2.0	4.5	4.5	4.5	4.5	4.5	4.5	55	98	25	3.0	4.5	59.3
14.01.2011	Tekka		2.0	2.0					4.5	4.5				64	17		2.0	4.5	40.5
17.01.2011	Tekka	2.0	2.0	2.0	4.9	2.0	2.0	4.5	4.5	10.5	4.5	4.5	4.5	15	27	3	2.5	5.5	14.8
19.01.2011	Tekka	2.0	2.0	2.0	2.0	2.0	2.0	4.5	4.5	4.5	4.5	4.5	4.5	21	46	16	2.0	4.5	27.7
21.01.2011	Tekka	2.0	2.0	4.9	2.0	2.0	2.0	4.5	9.1	13.3	11.0	9.6	4.5	116	80	6	2.5	8.7	67.3
24.01.2011	Tekka	2.0	4.4	5.3	2.0			4.5	9.6	13.3	13.7			74	67		3.4	10.3	70.5
28.01.2011	Tekka	2.0	2.0	4.4	2.0	2.0	2.0	4.5	10.5	12.3	11.0	9.1	4.5	74	128	42	2.4	8.7	81.3
31.01.2011	Tekka	2.0	2.0	2.0	2.0	2.0	2.0	4.5	24.2	21.9	21.5	13.7	4.5	103	13	22	2.0	15.1	46.0
02.02.2011	Tekka		4.9	6.8	4.8	5.8	4.9		13.3	12.8	11.0	9.1	4.5	46	100	50	5.4	10.1	65.3
04.02.2011	Tekka	2.0	2.0	2.0	2.0	4.4	2.0	4.5	4.5	9.4	12.3	12.8	4.5	43	157	28	2.4	8.0	76.0
07.02.2011	Tekka	2.0	2.0					12.8	11.7					87			2.0	12.3	87.0
09.02.2011	Tekka	2.0	2.0	2.0	2.0	2.0	2.0	4.5	4.5	4.5	4.5	4.5	4.5	72		28	2.0	4.5	50.0
11.02.2011	Tekka	2.0	2.0	2.0	2.0	2.0	2.0	14.6	18.3	20.6	12.8	14.2	4.5	78	87	25	2.0	14.2	63.3
14.02.2011	Tekka	2.0	2.0					9.1	11.0					9			2.0	10.1	9.0
16.02.2011	Tekka	2.0	4.1					4.5	14.3					20			3.1	9.4	20.0
21.02.2011	Tekka	2.0	2.0	2.0	2.0	2.0	2.0	4.5	14.6	19.2	16.5	11.0	4.5	108	33	32	2.0	11.7	57.7

Figure 3.1 Concentration of pollutant

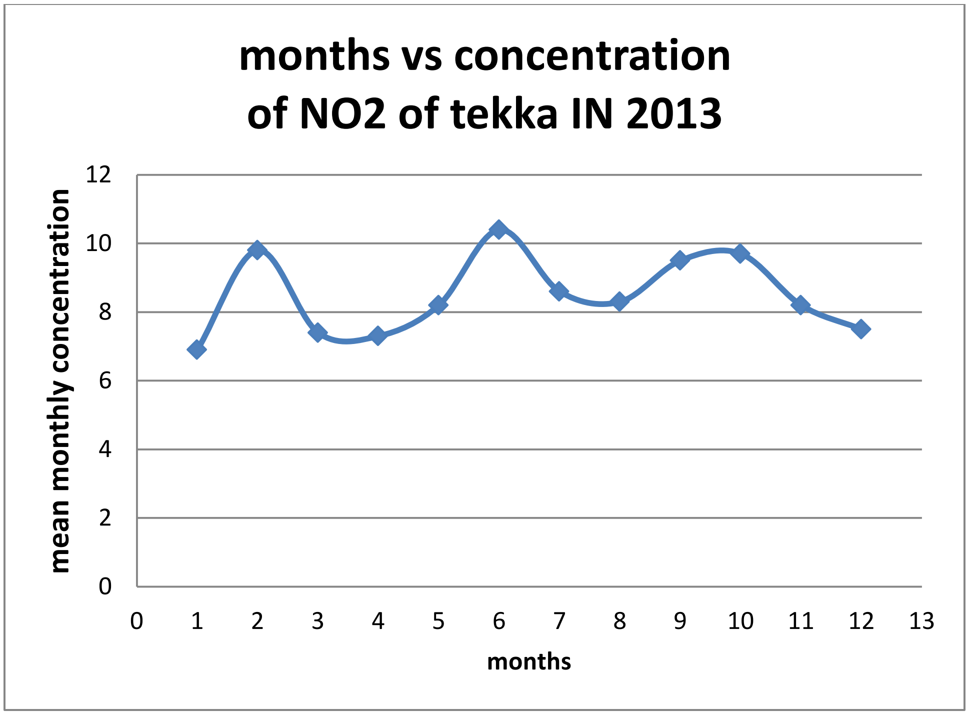


Figure 4.2

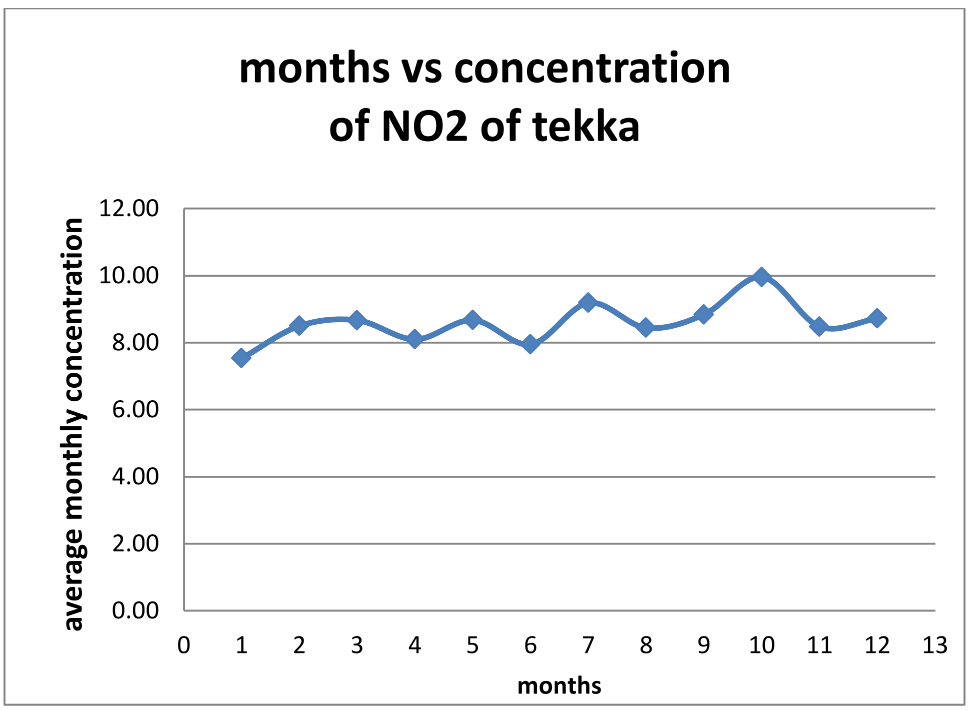


Figure 4.3

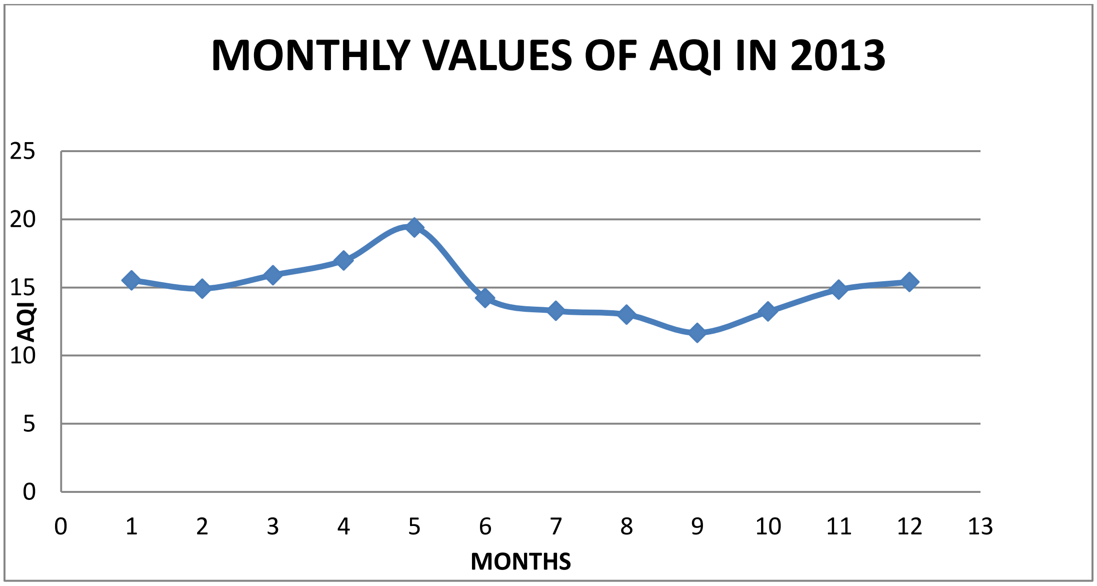

MONTHLY VALUES OF AQI IN 2013
AQI
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
MONTHS

Figure 4.4

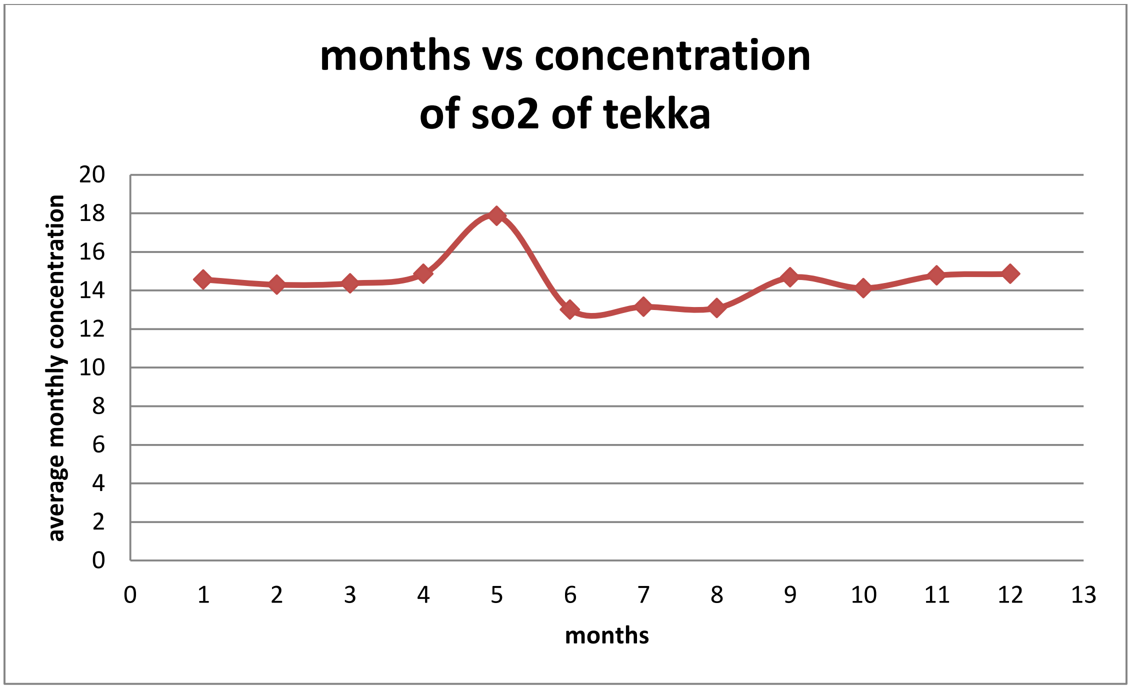


Figure 4.5

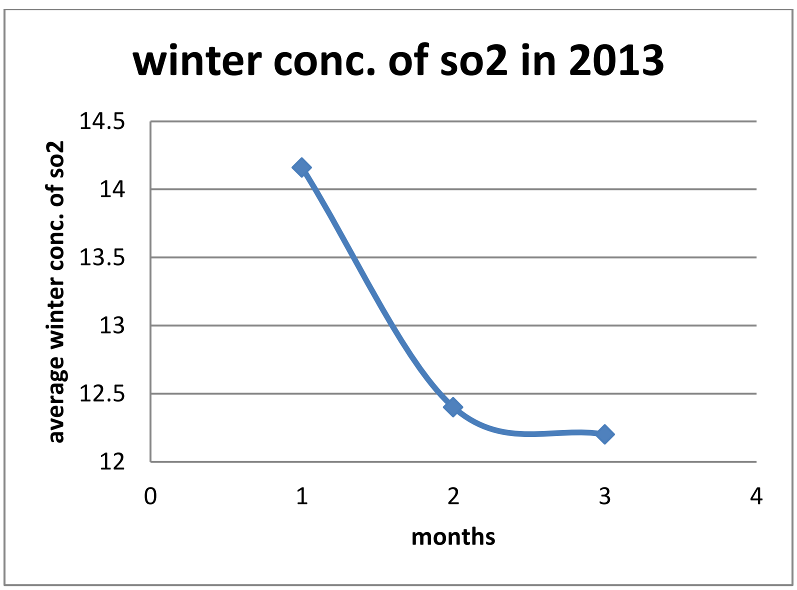


Figure 4.6

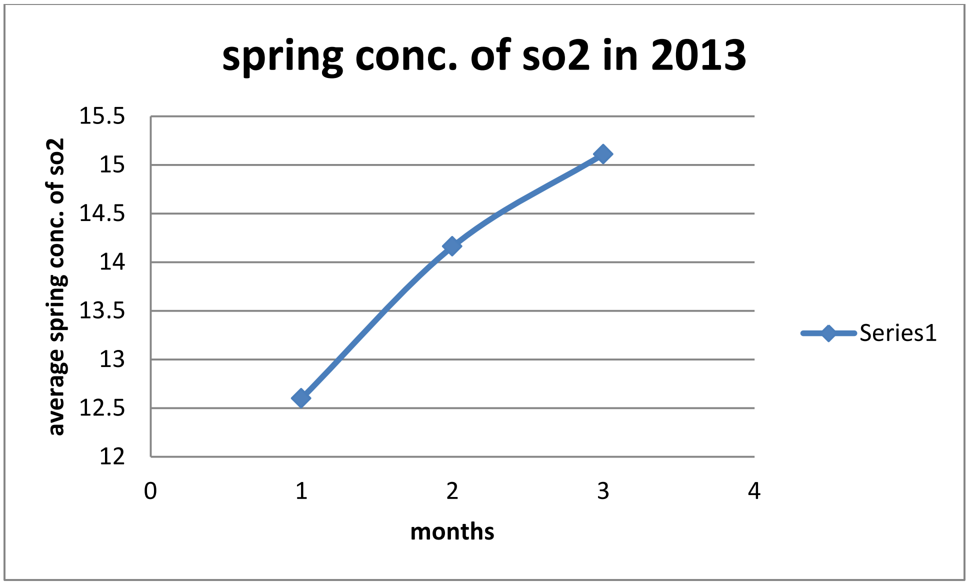


Figure 4.7

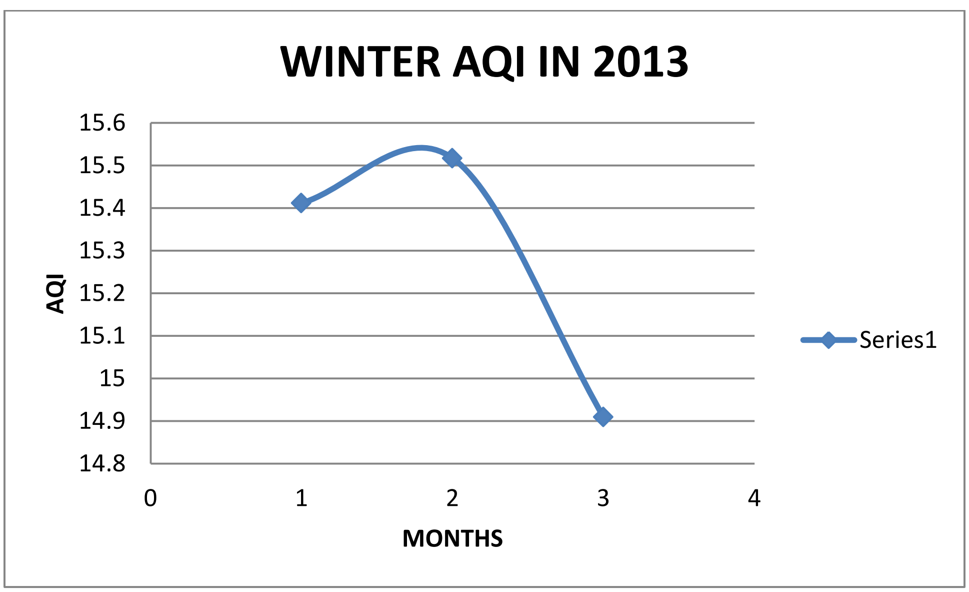


Figure 4.8

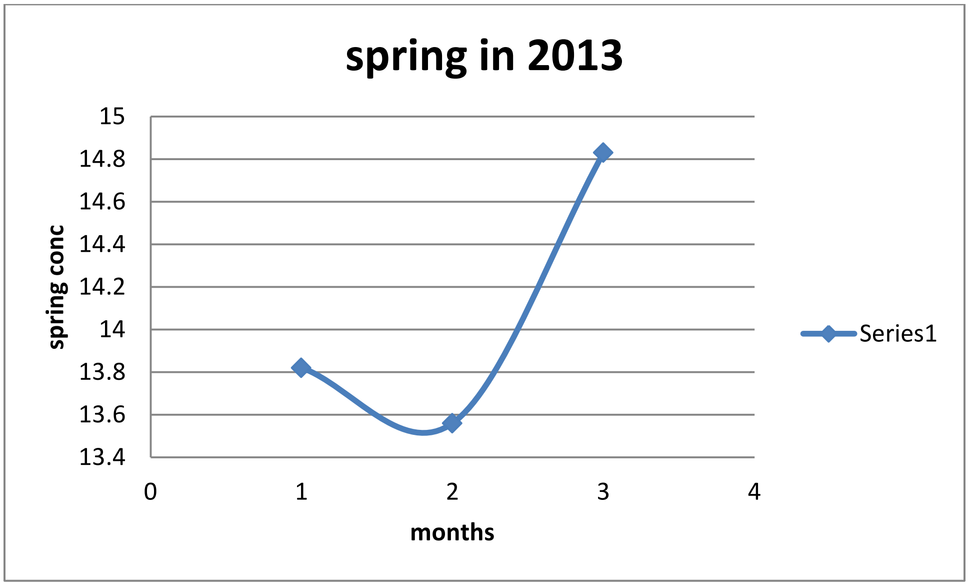


Figure 4.9

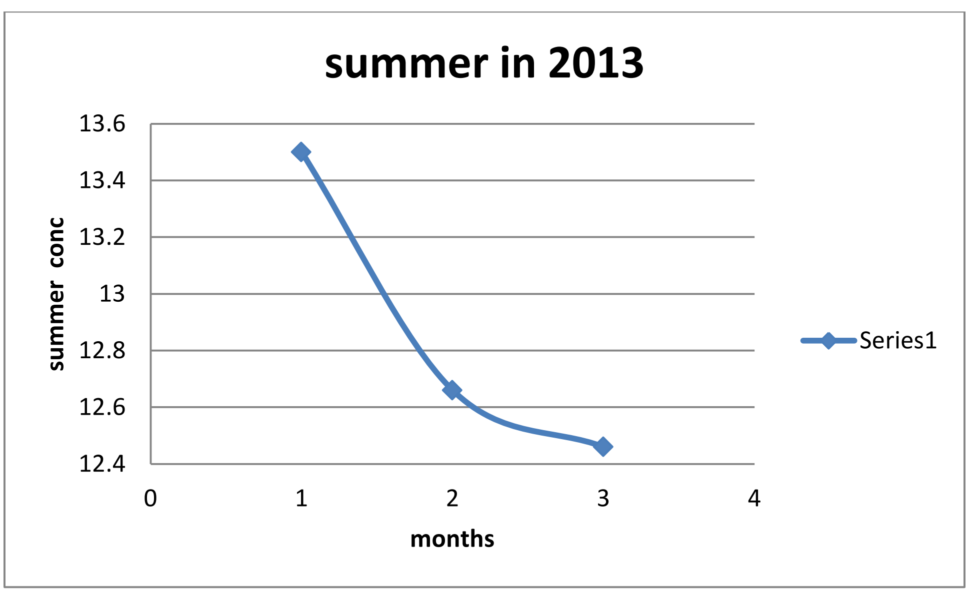


Figure 5.0

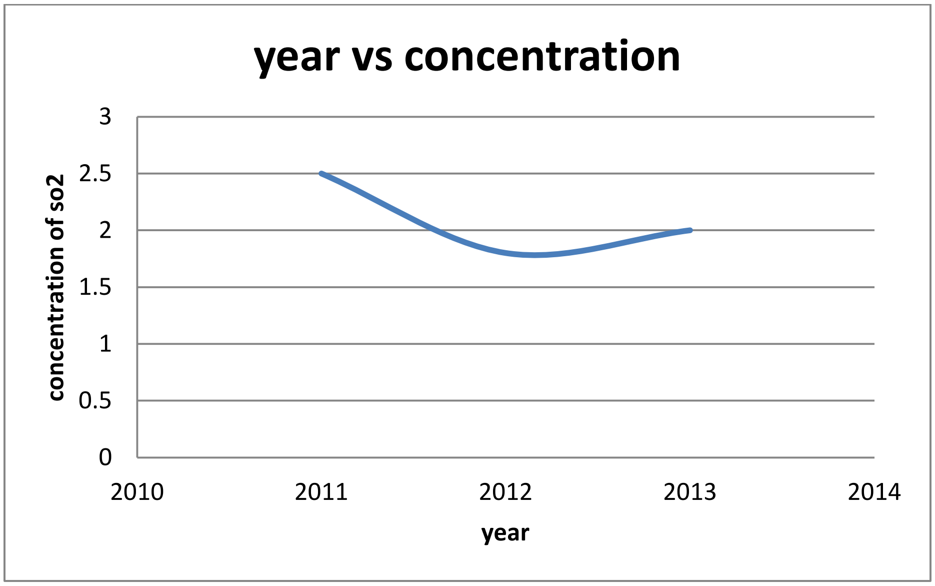


Figure 5.1

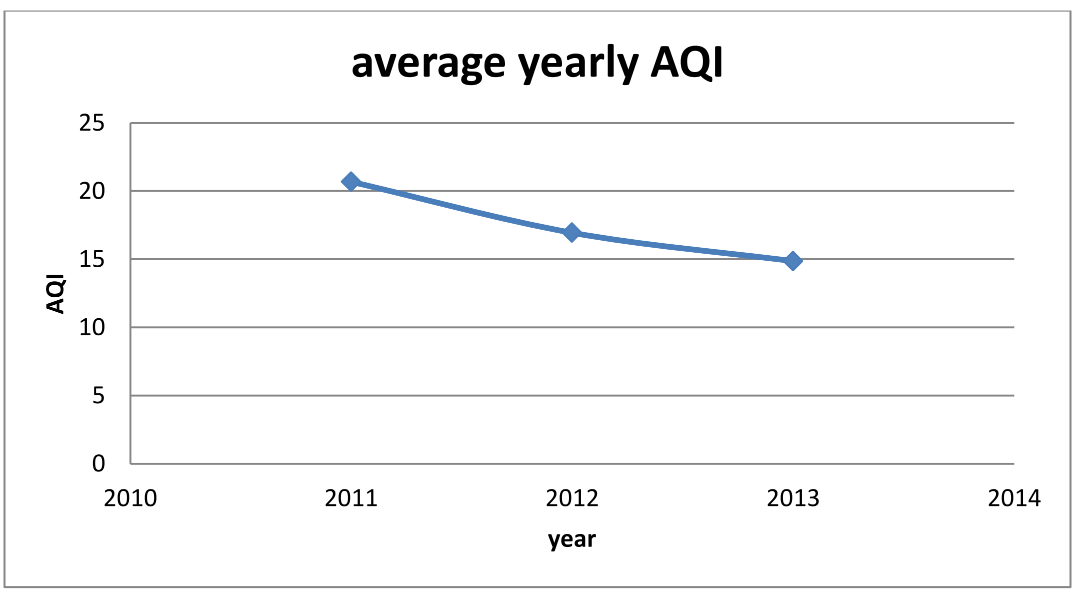


Figure 5.2

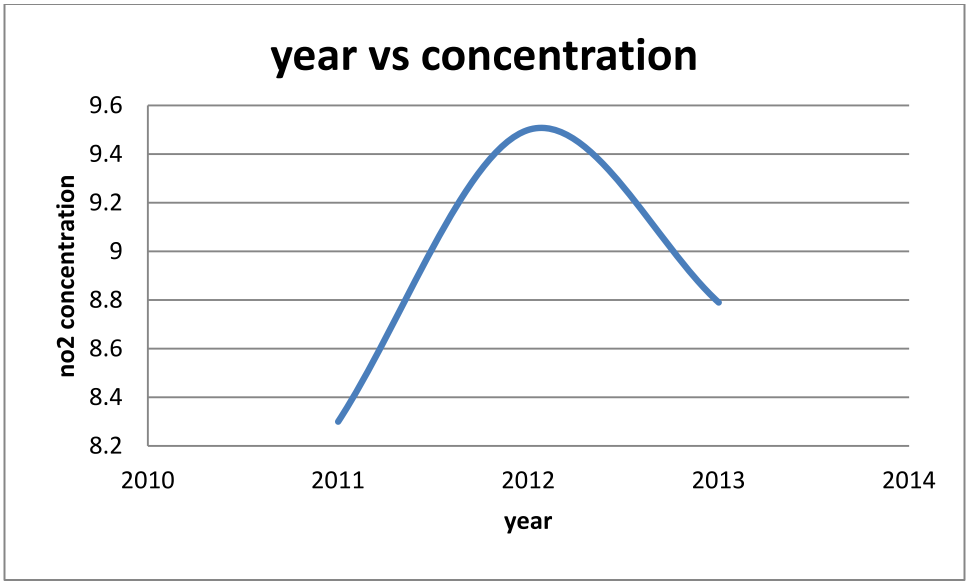


Figure 5.3

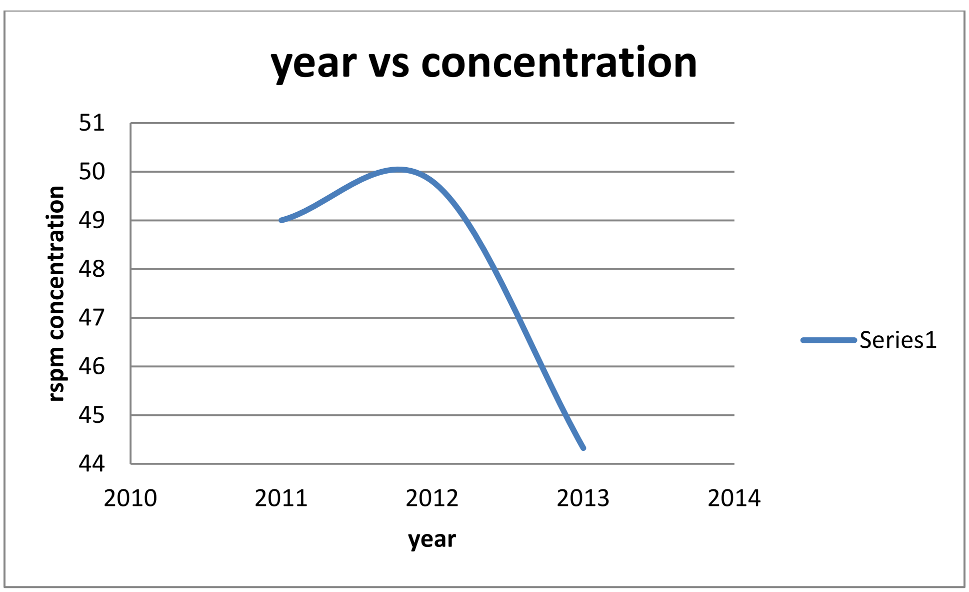


Figure 5.4

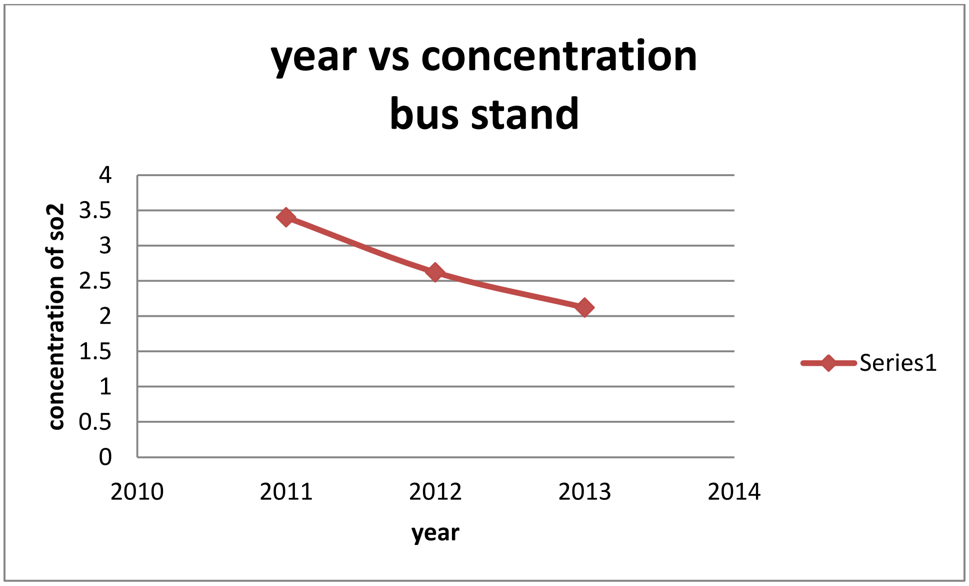


Figure 5.5

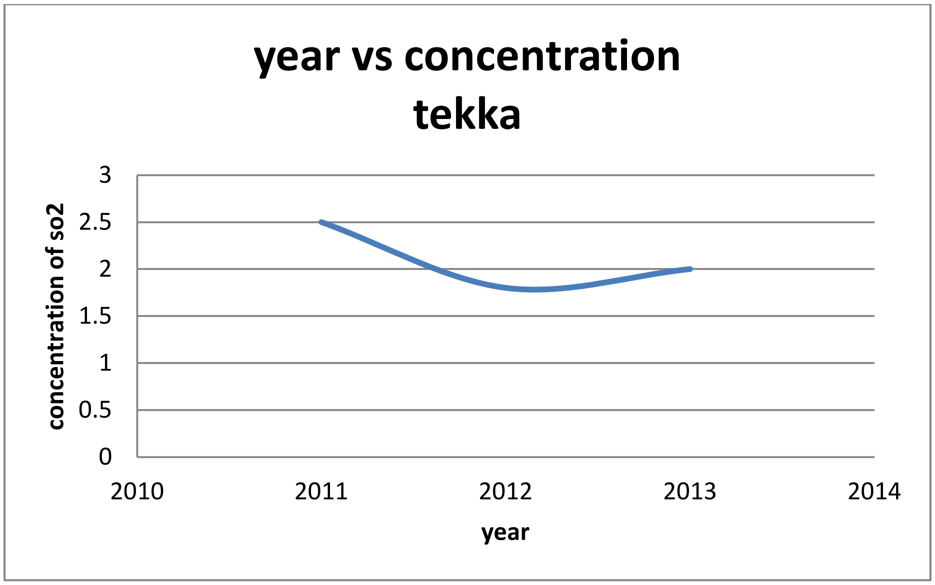


Figure 5.6

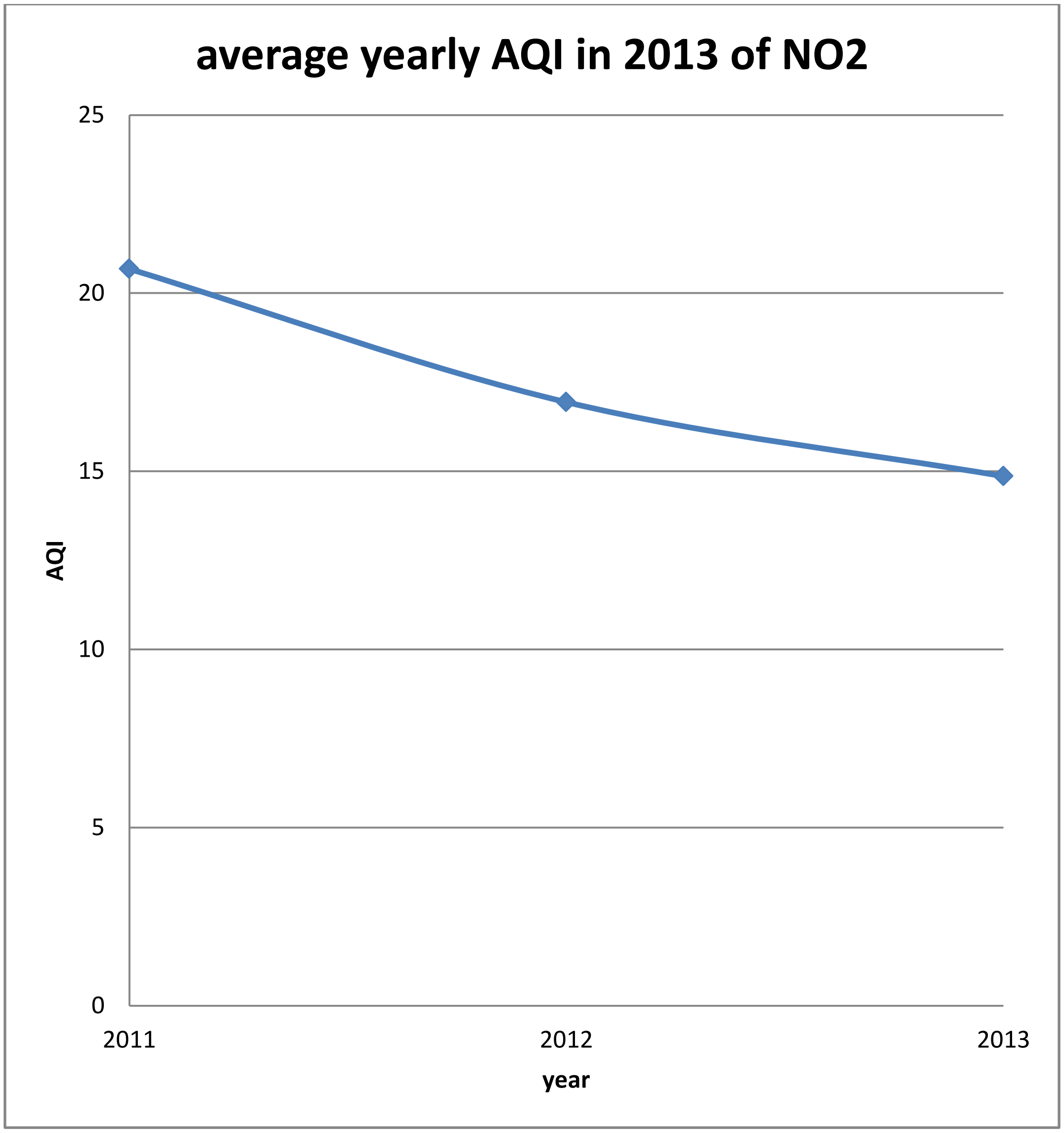
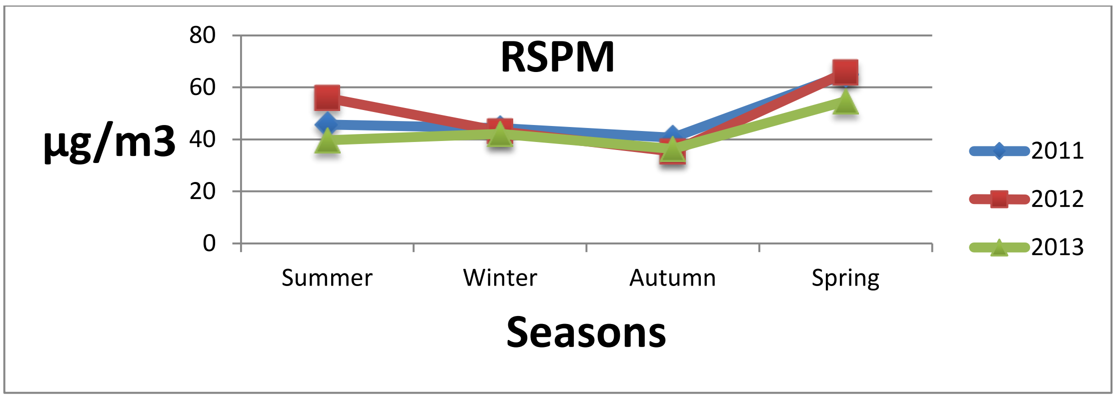

average yearly AQI in 2013 of NO2
25
20
15
10
5
0
AQI
2011
2012
2013
year

Figure 5.7


RSPM
µg/m3
80
60
40
20
0
Summer
Winter
Autumn
Spring
Seasons
2011
2012
2013

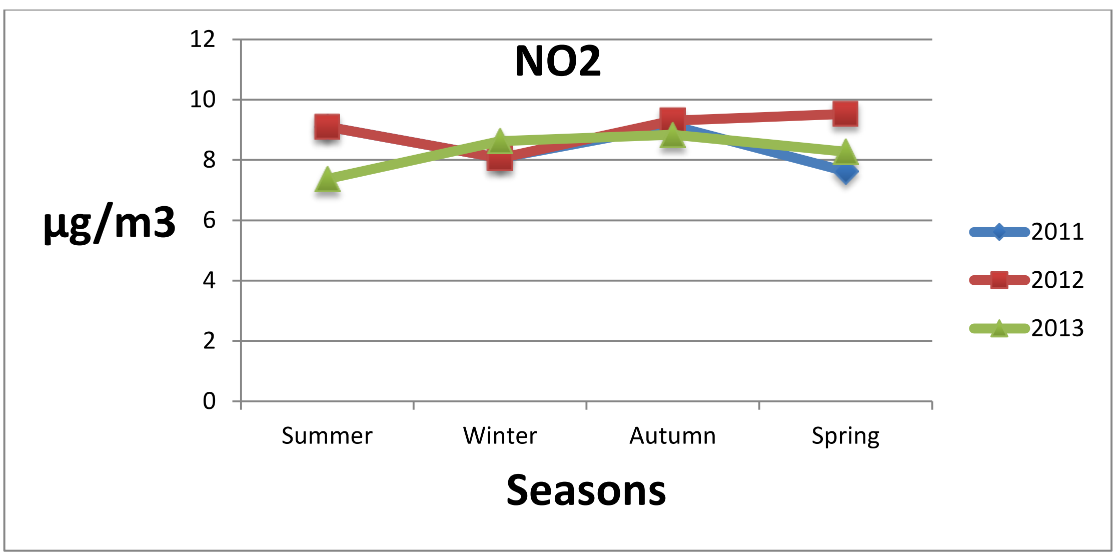

NO2
µg/m3
12
10
8
6
4
2
0
Summer
Winter
Autumn
Spring
Seasons
2011
2012
2013

Figure 5.8

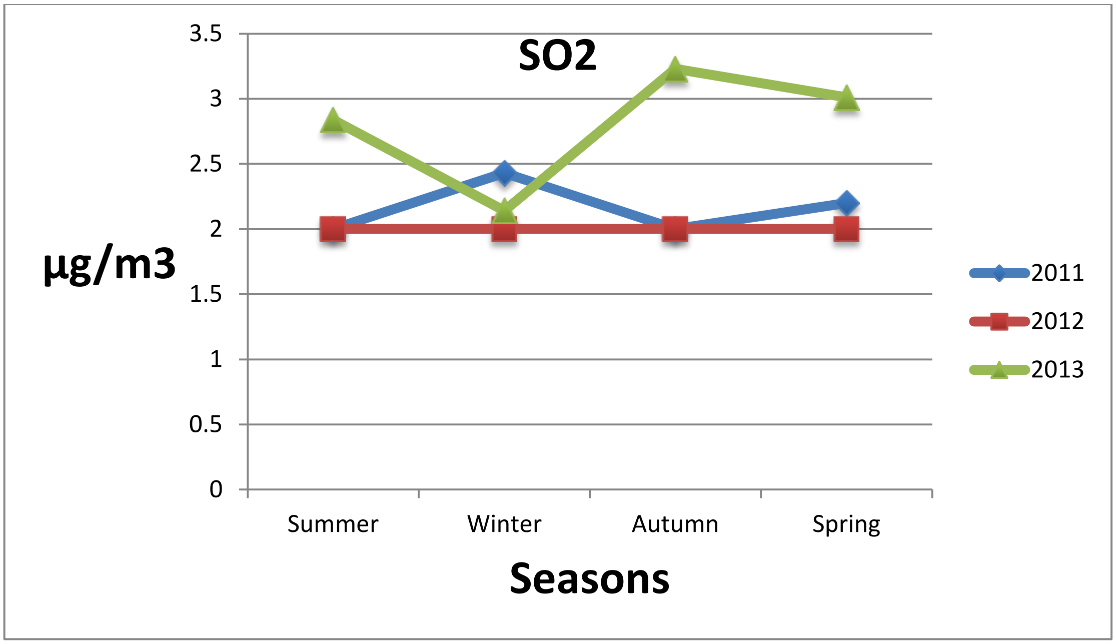


Figure 5.9

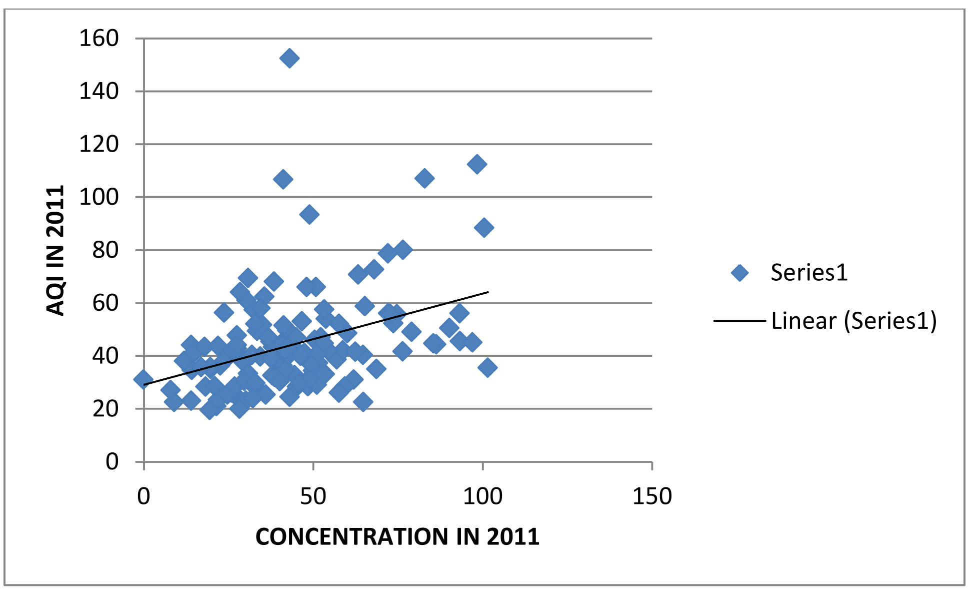


Figure 6.0: AQI VS CONCENTRATION

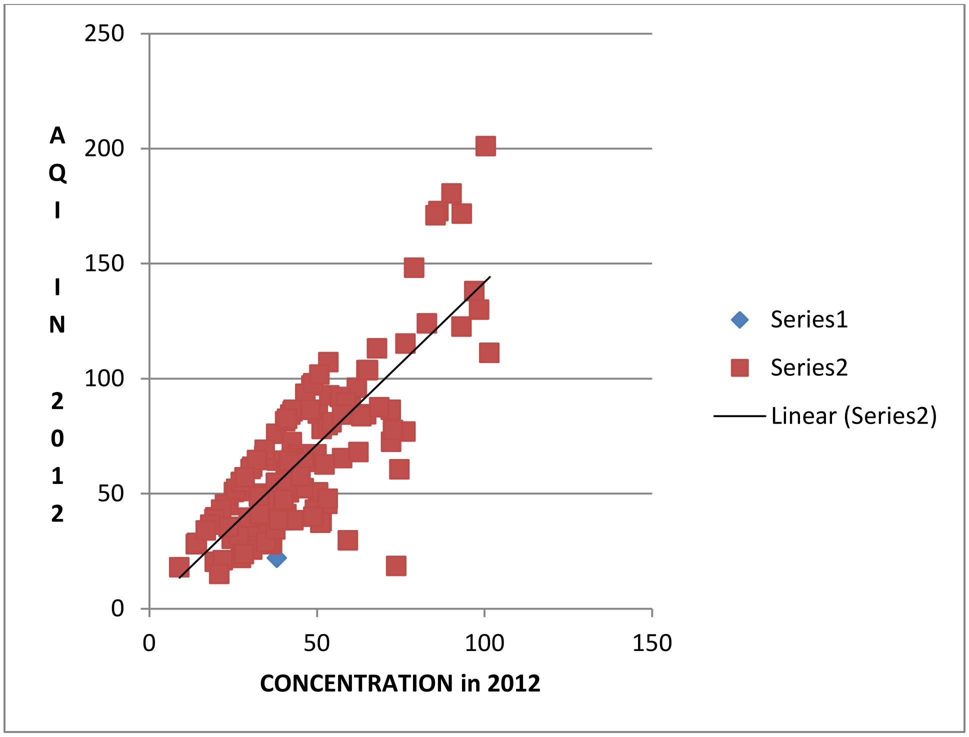


Figure 6.1: AQI VS CONCENTRATION

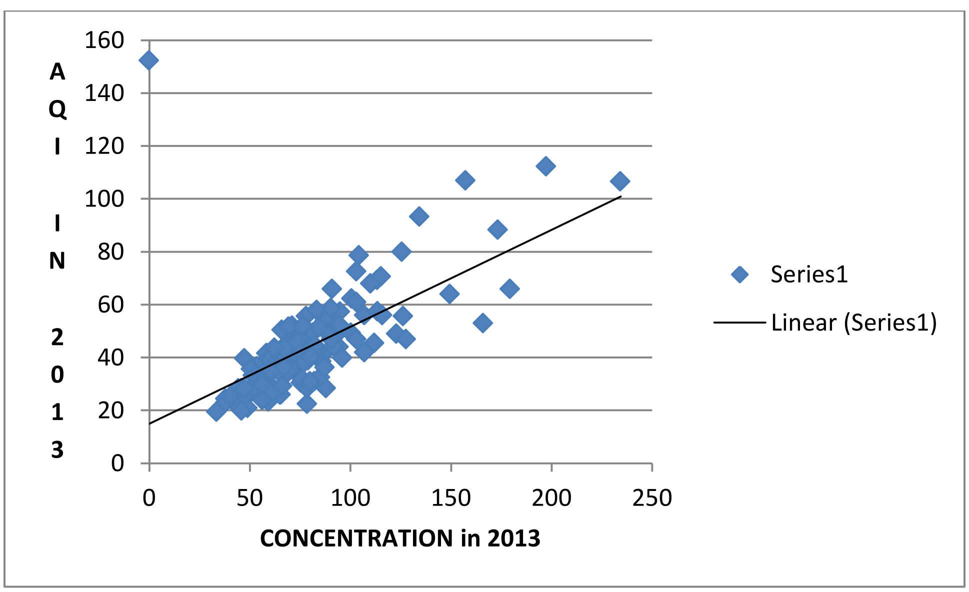


Figure 6.2: AQI VS CONCENTRATION

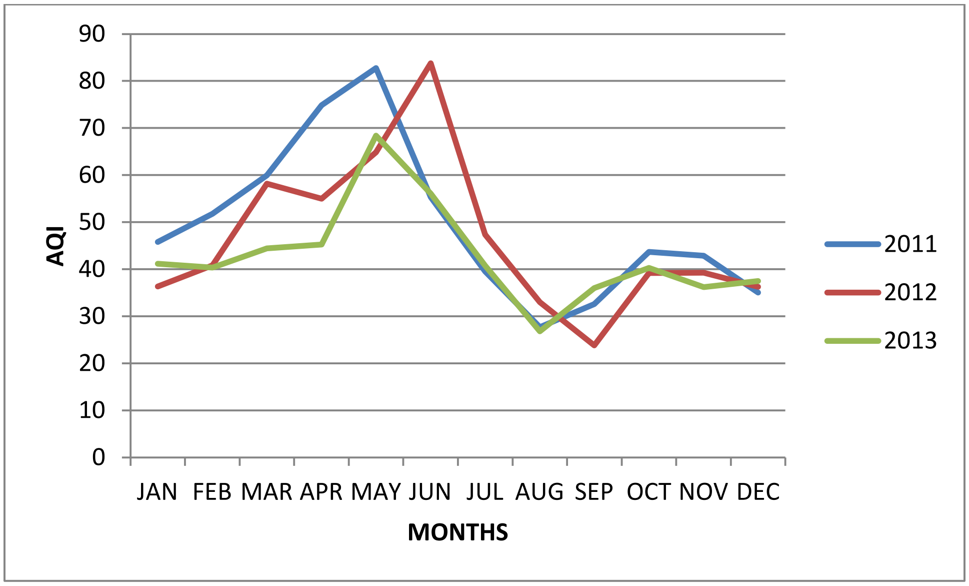


Figure 6.3: AQI VS MONTHS

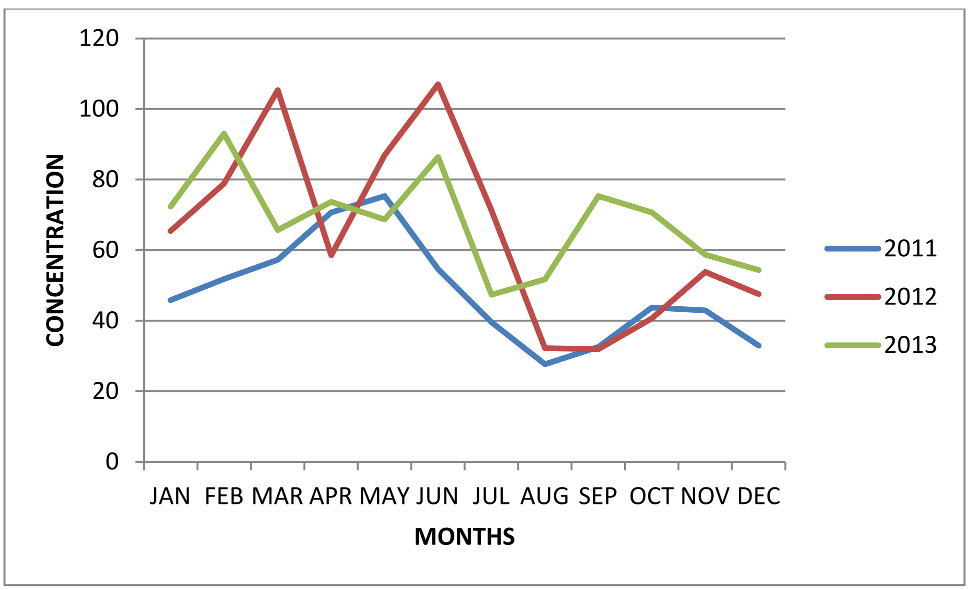


Figure 6.4: CONCENTRATION VS MONTHS

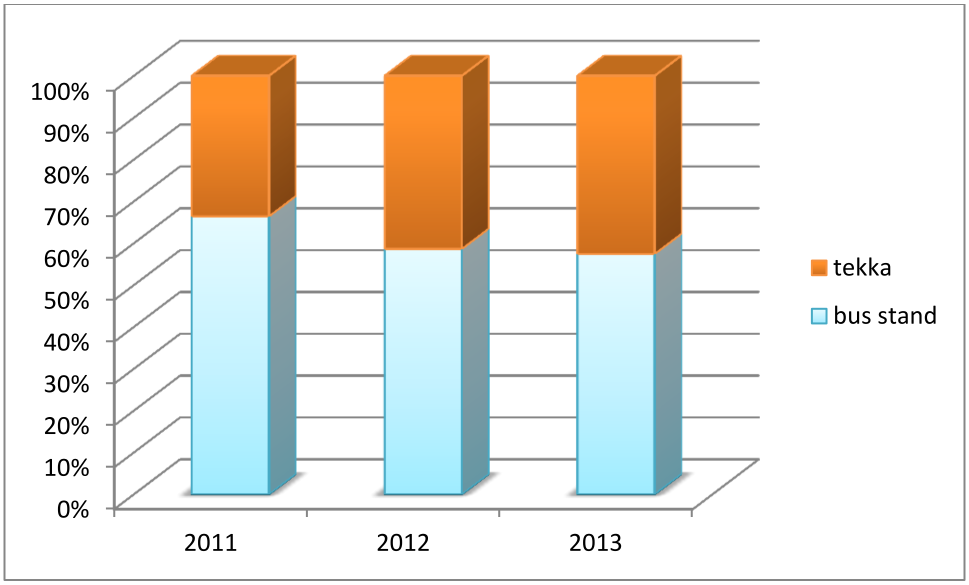


Figure 6.0: No2 conc. In 3 respective years

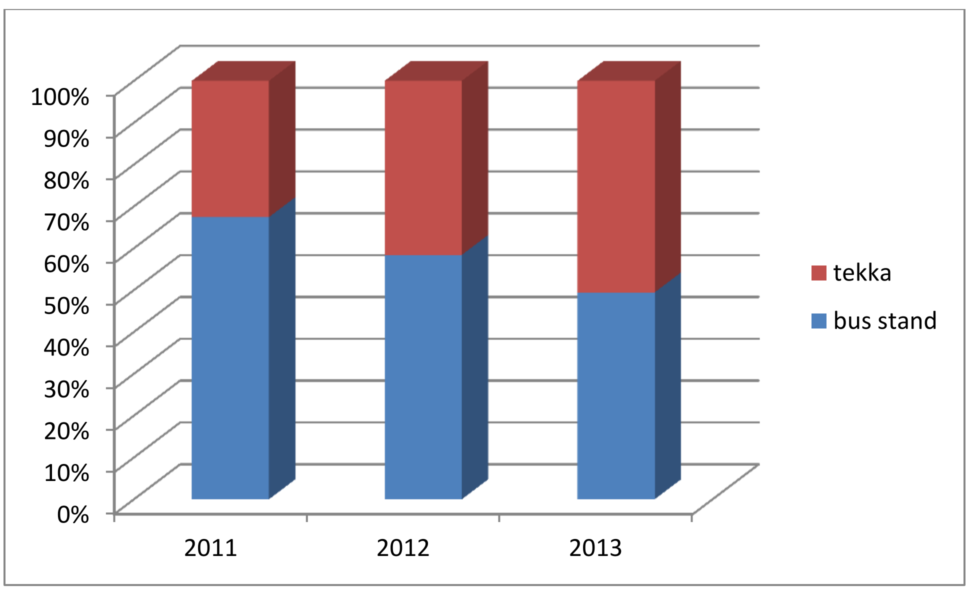


Figure 6.1: rspm conc. In 3 respective years

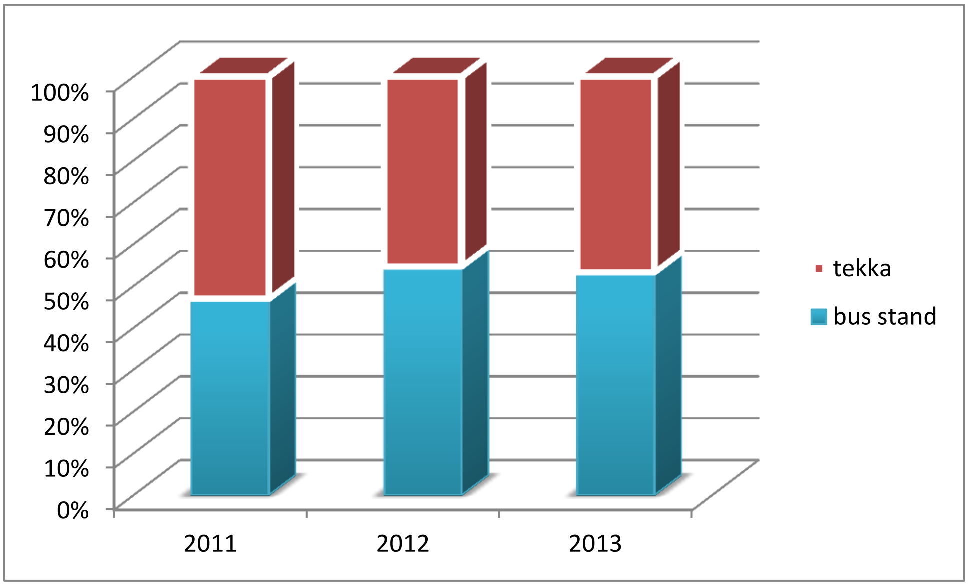


Figure 6.2: spm conc. In 3 respective years

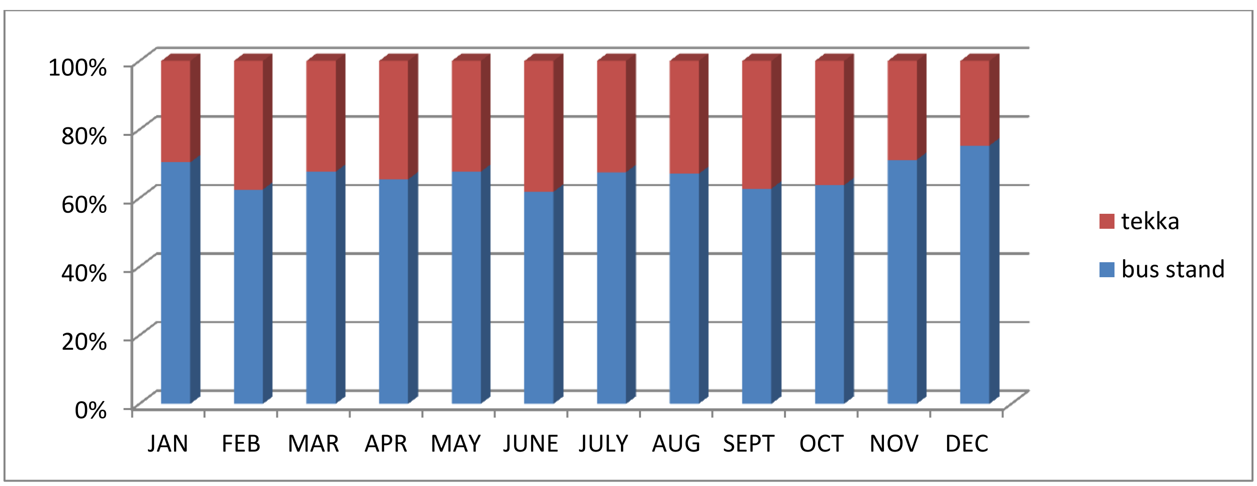


Figure 6.3: No2 conc. In months in 2011

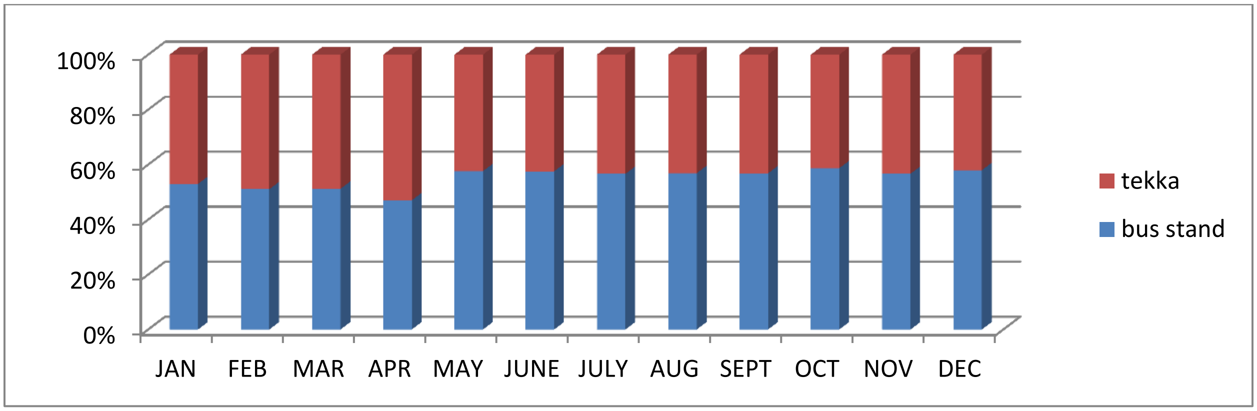


Figure 6.4: RSPM conc. In months in 2011

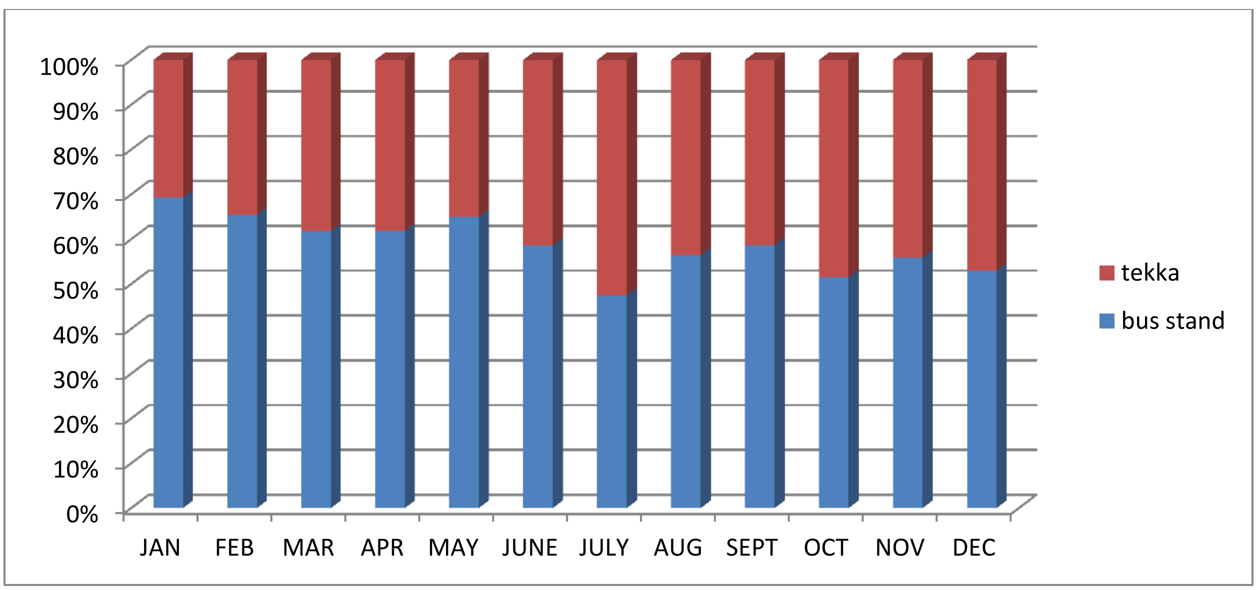


Figure 6.5: No2 conc. In months in 2012

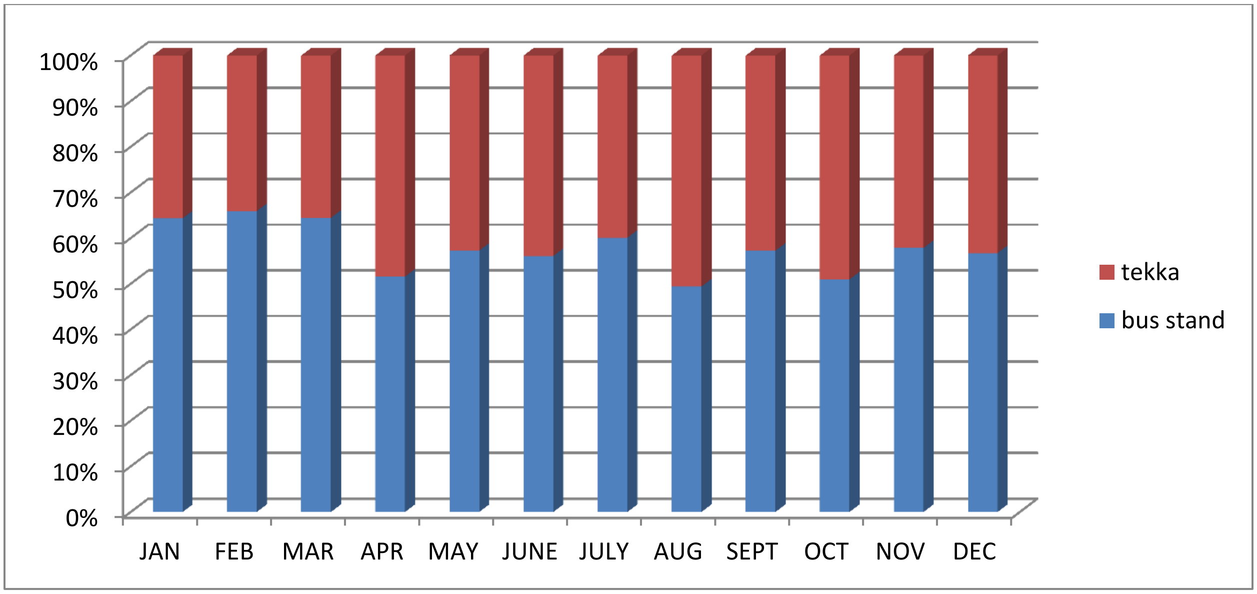


Figure 6.6: RSPM conc. In months in 2012

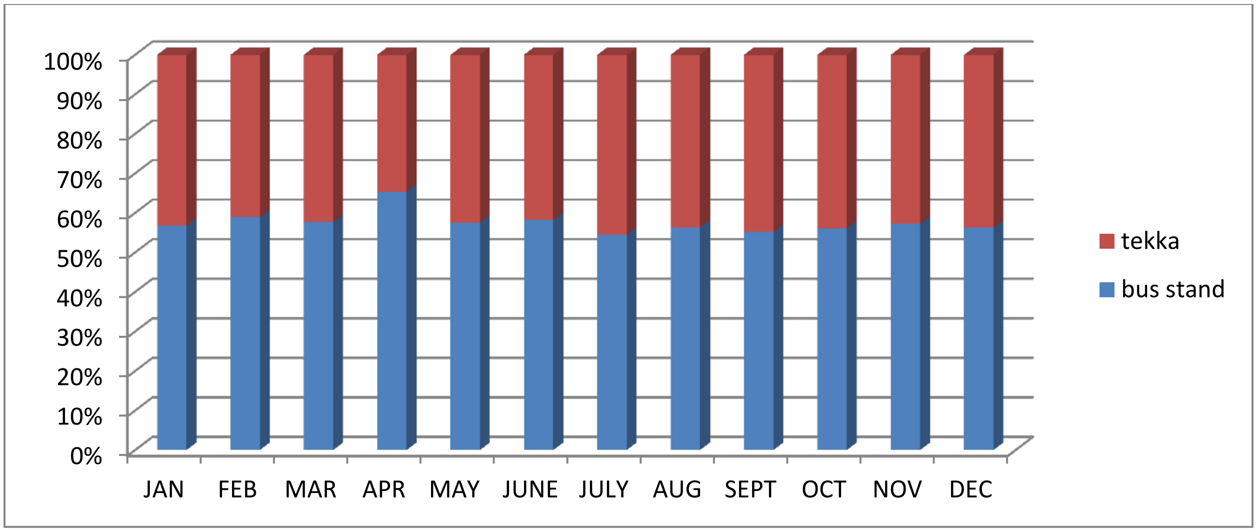


Figure 6.7: No2 conc. In months in 2013

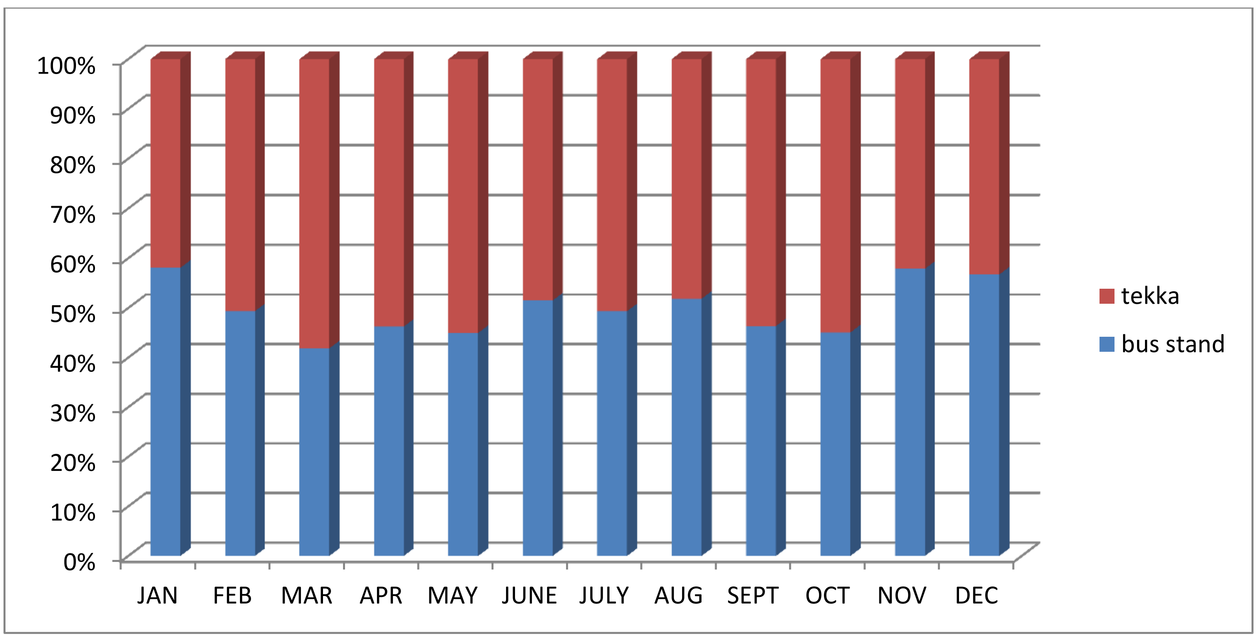


Figure 6.8: RSPM conc. In months in 2013

3.2 INTERPRETATION OF THE RESULTS

The above graphs are obtained by plotting graphs between time and concentration with time on x and conc. on y axis respectively

We can see in figures 4.1 and 4.2 respectively that the peak is higher in winter season as compared to summer season.this may be justified by saying that This period is dominated by cold, dry air and ground-based inversion with low wind conditions ($u \leq 1ms-1$), which occur frequently and increases the concentration of pollutants. The summer season (March, April, May) is governed by high temperature and high winds, the monsoon season (June, July, August) is dominated by rains and post-monsoon season is influenced (September, October, November) by moderate temperature and wind conditions.

increasing trends in figures of year 2013 is clear enough as different number of activities such as industrial works and vehicles increase is prominent in succeeding years.the same thing goes for year 2013 as well.the increase is also shown in data obtained below.

As well as the increase in concentrations of rspm and NO_2 and their peak value as shown in the figure 4.7 indicating increase in vehicles , power plants, industrial and other activities in the subsequent years.

CHAPTER-4

SIGNIFICANCE AND CONCLUSIONS

As for the health impact of air pollutants, AQI is an important indicator for general public to understand easily how bad or good the air quality is for their health and to assist in data interpretation for decision making processes related to pollution mitigation measures and environmental management

Categorizes the quality of air as good, moderate ,bad or severe

Help in estimating air quality standards and forecasting future needs
Big cities of India like Delhi are suffering from huge pollution problem and this technique can be very useful in restricting this problem

The ambient air quality near three busy traffic intersections in SHIMLA, India between 2011and 2013were
assessed using AQIs. The AQIs are calculated for criteria pollutants SO2, NOx, RSPM and SPM using the procedure
specified by the EPA. The result shows that air pollution levels at all the two intersections (i.e., AQM
stations) can be characterized as ‘‘good’’ and ‘‘moderate’’ for SO2 and NOx, for all the times during the years
2011–2013. The AQI values for RSPM concentrations were ‘‘good’’ and ‘‘moderate’’ 94% of the times between
2011 and 2013and 5% were ‘‘poor’’ and the remaining 1% were ‘‘good’’ and ‘moderate.’’ The summary of AQI
values of SPM concentrations indicated that 91% of the times during the years 2011–2013 are in the category of
‘‘good’’ and ‘‘moderate,’’ 7% ‘‘poor’’ and the remaining 2% ‘‘good’’ and ‘‘moderate.’’ Yearly AQI values of

RSPM and SPM are following a decreasing trend with more occurrences of ‘‘moderate’’ and ‘‘severe’’ values.

We can say that as of now shimla city air auality is between good and moderate but in future the condition can go worse or it pollution may rise to new heights. Hence the appropriate measures should be taken for this.

Now looking at a comparison of seasonal and annual average what is becoming evident is that spring is having highest concentration of **RSPM** even surpassing Annual average concentration. The main reasons for it can be relatively high windspeed in spring season especially in March, except spring, winter and summer seasons

The maximum concentration of pollutant occurred during winter months and a general trend of minimum values occurred during Monsoon season. Since frequent rains washes down the air borne particulates, period from July to September is much cleaner as compared to other months of the year. However, as the winter months have comparatively calm weather conditions, facilitating more stability to atmosphere and thus, slow dispersion of pollutants resulting in higher concentrations of pollutants in the ambient air concentration

Most importantly the **AQI** of any particular year or season, the AQI value is the value of particulate matter and the least is SO_2

In **SEASONAL** variations no particular trend can be noted as such.

In monthly mean or average variations slight fluctuations can be seen which can be attributed to some slight atmospheric variations

So in the end we can conclude that air quality of this shimla city is lying between moderate ranges and due to vehicular or other forms of pollution it is likely to increase. So necessary steps can be taken against this.

CHAPTER-5

ANNEXURE

AUTHORITY WISE NUMBER OF ALL VEHICLE IN STATE OF H.P. between 2013-2014

STA SHIMLA	2036
RTO SHIMLA	2029
RLA Shimla (rural)	1010
RLA Shimla(urban)	1087
total	**6162**

Between 2014-2015

STA Shimla	1939
RTO Shimla	1848
RLA Shimla(rural)	1209
RLA Shimla(urban)	1462
total	**6458**

Table 5.1

ESTIMATE OF DOMESTIC AND FOREIGN TOURIST ARRIVAL FOR THE YEAR 2012

Month	Bilaspur		Chamba		Hamirpur		Kangra		Kinnaur		Kullu
	I	F	I	F	I	F	I	F	I	F	I
Jan.	51724	6	26078	23	39585	0	107002	5185	0	0	83464
Feb.	51957	11	28290	39	45886	0	142230	5124	125	6	99516
Mar.	52124	17	35821	55	92132	0	161098	9537	20850	10	211658
Apr.	52428	19	45830	115	40138	0	232990	11237	23717	25	342797
May	117826	8	75001	97	59359		263365	15118	79328	2643	393845
June	97571	11	124531	96	43127	0	213866	13391	76328	2891	425553
July	76314	0	125824	69	50917	0	130271	8934	31247	2257	200807
Aug	87726	9	91224	85	42589	0	202589	6895	32452	1352	289919
Sept	74589	12	103280	89	53307	0	244961	8421	47927	3104	280176
Oct	178567	37	73110	95	105367	0	252476	17249	42369	987	342897
Nov	74145	4	112361	103	65124	3	113890	7894	48624	929	186589
Dec	62531	0	113168	108	45671	0	125564	6124	42367	656	225324
TOTAL	**977502**	**134**	**954518**	**974**	**683202**	**3**	**2190302**	**115109**	**445334**	**14860**	**3082545**

	Lahaul & Spiti		Mandi		Shimla		Sirmour		Solan		Una
F	I	F	I	F	I	F	I	F	I	F	I
3673	0	0	47422	509	198866	9160	66036	139	47251	418	56843
3596	0	0	47544	511	180290	7124	64618	151	46607	606	61164
6874	10	8	47856	516	192286	13812	64576	258	64683	892	81785
11608	2500	55	48904	532	347568	11895	95784	249	80224	523	58637
17385	69918	2236	75976	983	434490	13070	85581	436	86510	930	73159
16214	65156	6891	92990	924	463945	13257	114402	281	98119	869	92361
15367	41235	16357	68964	914	213647	14367	78413	349	79357	837	103567
17524	49178	10537	79629	948	278333	14551	67382	236	73565	238	88236
12658	52364	5957	78634	856	214897	14967	62357	351	75639	262	95697
14894	42367	4256	88987	1039	231647	15367	92567	218	92371	524	215697
8893	44567	858	65234	712	170239	14123	112369	166	57143	350	92146
15214	29367	258	56321	624	269124	16978	44569	254	66421	369	86354
143900	**396662**	**47413**	**798461**	**9068**	**3195332**	**158671**	**948654**	**3088**	**867890**	**6818**	**1105646**

I-	**Indian**		**15646048**
F-	**Foreigner**		**500284**
	Total		**16146332**

Increase on total: 7.00%

Table 6.1

ESTIMATE OF DOMESTIC AND FOREIGN TOURIST ARRIVAL FOR THE YEAR 2013

Month	Bilaspur		Chamba		Hamirpur		Kangra		Kinnaur		Kullu
	I	F	I	F	I	F	I	F	I	F	I
Jan.	58962	9	30318	34	45226	0	120112	6326	0	0	84300
Feb.	60239	18	33383	23	52898	0	159651	5850	0	0	111466
Mar.	56527	22	41280	42	48326	0	179236	10253	22631	16	251873
Apr.	194236	36	51497	100	142137	0	267891	12637	38561	37	291377
May.	108719	7	80438	62	52841	0	256719	12469	61986	2549	342645
June	99230	2	126644	71	40969	0	194083	11130	0	94	330910
July	81931	6	128930	103	53080	0	119380	4140	0	73	140283
August	88691	9	108331	58	44237	0	157533	5722	0	254	271828
Setp	75882	15	104329	66	48512	0	210666	6736	0	180	296986
Oct	181749	43	79113	33	95615	3	214322	13928	0	58	274318
Nov	75454	3	104531	63	61609	1	103148	7601	0	16	167931
Dec	63592	2	105229	8	43728	0	115287	5803	0	5	202792
TOTAL	**1145212**	**172**	**994023**	**663**	**729178**	**4**	**2098028**	**102595**	**123178**	**3282**	**2766709**

	Lahaul & Spiti		**Mandi**		**Shimla**		**Sirmour**		**Solan**		**Una**	
F	I	F	I	F	I	F	I	F	I	F	I	F
3713	0	0	53282	751	220746	9642	74214	228	55491	554	65947	15
4039	0	0	54675	573	190874	8191	72377	180	53131	680	61332	31
8180	2485	5	65679	619	215637	12561	73137	295	70714	925	61235	14
9867	3842	40	70124	621	376256	13362	102567	354	90365	630	155413	23
15125	43297	1529	82787	1025	442126	14121	105634	521	92634	1020	86239	15
11855	19114	522	94720	942	137419	13055	78647	219	71478	461	96554	5
10718	20116	646	77898	900	182402	14434	57831	276	62171	544	106937	11
11537	18367	617	80855	938	219114	13617	50572	160	54254	174	91638	13
11899	3997	996	79813	872	238410	15901	52089	160	78097	275	87850	0
11916	3043	505	90317	1062	270150	16870	54693	195	96284	514	205422	7
7560	465	37	66492	725	190319	14928	57427	205	55294	342	86383	7
12932	0	0	57497	635	309538	17324	61446	216	70912	357	80993	0
119341	**114726**	**4897**	**874139**	**9663**	**2992991**	**164006**	**840634**	**3009**	**850825**	**6476**	**1185943**	**141**

Indian		**14715586**
Foreigner		**414249**
Total		**15129835**

Total change **(-) 6.30%**

Table7.1

SAMPLE CALCULATIONS OF AQI

Value of SO_2 6AM - 10AM	Value of SO_2 10AM - 2PM	Value of SO_2 2PM - 6PM	Value of SO_2 6PM - 10PM	Value of SO_2 10PM - 2AM	Value of SO_2 2AM - 6AM	Value of NOx 6AM - 10AM	Value of NOx 10AM - 2PM	Value of NOx 2PM - 6PM	Value of NOx 6PM - 10PM	Value of NOx 10PM - 2AM	Value of NOx 2AM - 6AM	RSPM 6AM-2PM	RSPM 2PM-10PM	RSPM 10PM-6AM									
4.1	5.3	2.0	5.8	2.0	2.0	4.5	4.5	4.5	4.5	4.5	4.5	19	39	12	3.5	4.5	23.3	0	80	0	100	4.41667	(
	2.0	2.0	2.0	4.9	6.3		4.5	4.5	4.5	4.5	4.5	44	12	3	3.4	4.5	19.5	0	80	0	100	4.3	(
	2.0	2.0	2.0	2.0	2.0		9.1	11.4	4.5	4.5	4.5	32	104	45	2.0	6.8	60.3	0	80	0	100	2.5	(
2.0	2.0	2.0	4.4	6.3	7.8	4.5	4.5	4.5	4.5	4.5	4.5	22	69	25	4.1	4.5	38.7	0	80	0	100	5.10417	(
2.0	2.0	4.4	2.0	5.3	2.0	4.5	4.5	4.5	4.5	4.5	4.5	55	98	25	3.0	4.5	59.3	0	80	0	100	3.6875	(
	2.0	2.0					4.5	4.5				64	17		2.0	4.5	40.5	0	80	0	100	2.5	(
2.0	2.0	2.0	4.9	2.0	2.0	4.5	4.5	10.5	4.5	4.5	4.5	15	27	3	2.5	5.5	14.8	0	80	0	100	3.10417	(
2.0	2.0	2.0	2.0	2.0	2.0	4.5	4.5	4.5	4.5	4.5	4.5	21	46	16	2.0	4.5	27.7	0	80	0	100	2.5	(
2.0	2.0	4.9	2.0	2.0	2.0	4.5	9.1	13.3	11.0	9.6	4.5	116	80	6	2.5	8.7	67.3	0	80	0	100	3.10417	(
2.0	4.4	5.3	2.0			4.5	9.6	13.3	13.7			74	67		3.4	10.3	70.5	0	80	0	100	4.28125	(
2.0	2.0	4.4	2.0	2.0	2.0	4.5	10.5	12.3	11.0	9.1	4.5	74	128	42	2.4	8.7	81.3	0	80	0	100	3	(
2.0	2.0	2.0	2.0	2.0	2.0	4.5	24.2	21.9	21.5	13.7	4.5	103	13	22	2.0	15.1	46.0	0	80	0	100	2.5	(
	4.9	6.8	4.8	5.8	4.9		13.3	12.8	11.0	9.1	4.5	46	100	50	5.4	10.1	65.3	0	80	0	100	6.8	(
2.0	2.0	2.0	2.0	4.4	2.0	4.5	4.5	9.4	12.3	12.8	4.5	43	157	28	2.4	8.0	76.0	0	80	0	100	3	(
2.0	2.0					12.8	11.7					87			2.0	12.3	87.0	0	80	0	100	2.5	(
2.0	2.0	2.0	2.0	2.0	2.0	4.5	4.5	4.5	4.5	4.5	4.5	72		28	2.0	4.5	50.0	0	80	0	100	2.5	(
2.0	2.0	2.0	2.0	2.0	2.0	14.6	18.3	20.6	12.8	14.2	4.5	78	87	25	2.0	14.2	63.3	0	80	0	100	2.5	(
2.0	2.0					9.1	11.0					9			2.0	10.1	9.0	0	80	0	100	2.5	(

Figure 6.9: sample AQI calculations

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