Economic Growth in India and Environmental Kuznets Curve: State-wise Analysis

Thesis submitted in partial fulfillment of the requirements for the award of the Degree of

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in
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Under the supervision of
DR (MS) RAVI KIRAN

By
HIMANI
Registration No. 850901001

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SCHOOL OF MANAGEMENT AND SOCIAL SCIENCES
THAPAR UNIVERSITY
PATIALA 147004

CERTIFICATE

I hereby certify that the work which is being present in this thesis entitled ***'Economic Growth in India and Environmental Kuznets Curve: A Sector wise Analysis'*** *in partial fulfillment of the requirements for award of the Degree of* ***Master of Philosophy in Economics***, *submitted in* ***School of Management and Social Sciences, Thapar University, Patiala***, *is an authentic record of my own work carried out under the supervision of Dr (Ms) Ravi Kiran, Associate Professor, School of Management and Social Sciences.*

The matter presented in this thesis has not been submitted for the award of any degree of this or any other University.

(Himani Bansal)
(Registration No. 850901001)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Dr (Ms) Ravi Kiran
Supervisor
Associate Professor,
School of Management and Social Sciences,
Thapar University,
Patiala

Countersigned by:

30/6/x

Head,
School of Management and Social Sciences,
Thapar University, Patiala.

1.7.10

Dr R.K. Sharma
Dean (Academic Affairs),
Thapar University, Patiala.

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(Himani Bansal)

ABSTRACT

Sustainable Development is most common phrase used by the world economies. Sustainable Development means economic development with ecological sustainability. In this study , 24 states have been taken. These states are divided in 3 parts developed, developing and less developed states. The data taken for analysis is from 2004 – 2008. Moreover, 4 pollutants are taken Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur dioxide (SO2), Oxides of Nitrogen (NOx). The study concludes that oxides of nitrogen is partially accepted. In case of sulphur dioxide, the environmental Kuznets curve is not applicable for Sulphur dioxide (SO_2) emission. The research of for Respirable Suspended Particulate Matter shows that hypothesis is rejected. Hence, environmental Kuznets curve is not applicable for Respirable Suspended Particulate Matter (RSPM). Whereas, Suspended Particulate Matter is showing is partial acceptance of hypotheses. It means some of the states are showing inverted U-shaped curve and some of states are showing some other results.

CHAPTER I

AN OVERVIEW OF ECONOMIC GROWTH AND ENVIRONMENT KUZNET'S CURVE IN INDIA

1. Introduction

Over years, changes in government policies like privatization, liberalization and globalization has given a new boost and opportunity to economy to work freely. As a result, economy starts growing at faster rate. But these reforms had created a tremendous pressure on environment resources like forest, land, water, and air. These changes have made the market too competitive that nobody has time to think about public properties like environment and its resources. Being a public good, improvement in environment is the responsibility or business of everybody but everybody thinks why me, which results in nobody. Means, everybody is there to pollute environment but nobody is there to protect it or to clean it. Increasing population, industrialization, Laissez-faire economies, poverty and urbanization are also some of the other factors responsible for environmental degradation.

Sustainable Development is most common phrase used by the world economies. Sustainable Development means economic development with ecological sustainability. According to Brunt land commission 1987, "sustainable development means meeting the needs of present generation without compromising the needs of future generations". But if we see the reality every economy is concern about its GNP. GNP defines sum total of economic production of goods and services on the basis of transaction in the market in a year. Calculation of GNP ignores the cost of depleting the environment resources. Every economy wants to beats the other economy and wants to be at top. Not only economies but individuals are also running after each other to attain highest ranking in competitive market, ignoring what damages they are causing to environment and its resources, which will indirectly affect their health. Failure of Kyoto protocol project is one example. This project fails because it imposes limit to the economic growth in order to reduce carbon emissions.

But have you ever think about: What environment gives us and what we are giving back to environment? What is the carrying capacity of environment? What will be the future, if natural resources depletion and environment degradation is done in the same way? Can we move ahead to economic growth with sustainability? Which sector of the economy is creating more of environment degradation, is it poor countries, developing countries or developed countries? Related to this, different schools of economist have given different view. Some says microeconomic policies itself will promote environment sustainability (like, 1998) where as some ecological economics such as Daly (1991,1996) has suggested that growth should be limited rather than exponential growth to attain sustainable economic scale as resources are limited. Before proceeding farther, we will discuss but is environment and types of environment pollutions.

1.2 Natural Environment and its resources

The environment, encompasses all living and non-living things occurring naturally on Earth. Some of natural resources are essential for our survival while others are used for satisfying our wants. Natural resources may be further classified in different ways:

On the basis of origin, resources may be divided into:

- *Biotic* - Biotic resources are obtained from the biosphere, such as forests and their products, animals, birds, fish and other marine organisms. Mineral fuels such as coal and petroleum are also included in this category because they formed from decayed organic matter.
- *Abiotic* – Abiotic resources comprise of non-living things. Examples include land, water, air and ores such as gold, iron, copper, silver etc.

With respect to renewability, natural resources can be categorized as follows:

- Renewable resources: like sunlight, air, wind, etc., are included in this category. These resources are those resources which can be replenished or reproduced easily. Many renewable resources can be depleted by human use, but may also be replenished, thus maintaining a flow. Some of these, like agricultural crops, take a short time for renewal; others, like water, take a comparatively longer time, while still others, like forests, take even longer.

- Non-renewable resources: Minerals and fossils are included in this category. Since their rate of formation is extremely slow, they cannot be replenished once they get depleted like coal and petroleum cannot be recycled.

1.3 Pollutants and its types

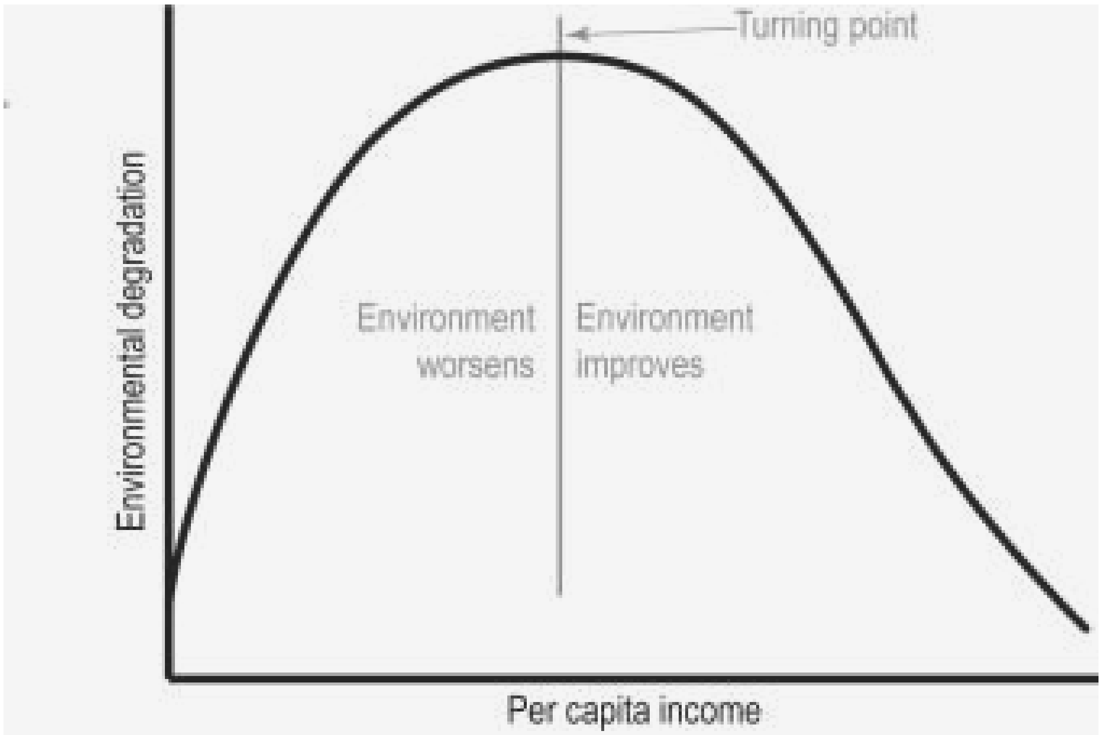
In general, substance introduced into the environment has adversely affected the usefulness of a resource. A pollutant may cause long or short-term damage to the growth rate of plant or animal species, or by interfering with human amenities, comfort, health, or property values.

The following are some of the type of pollutants. They are:

- Air Pollutants
- Water Pollutants
- Deforestation
- Soil Degradation and etc.

1.4 Environmental Kuznets Curve

In 1955, Nobel Laureate Simon Kuznets gave a famous hypothesis an inverse 'U' income-inequity relationship named as Kuznets Curve. In this hypothesis according to Kuznet, at initial level income inequality increases as income rise and reach to peak where average income level is attained and further declines with increase in income level. Later economist Grossman and Krueger in 1995 found this hypothesis can be used in context of environment representing the income-pollution relationship and it was named as "Environmental Kuznets Curve". Environmental Kuznets Curve proposes that there is an inversed U-shape relationship between environmental degradation and income per capita. In EKC hypothesis contends that pollution increases initially as a country develops its industry and thereafter declines after reaching a certain level of economic progress which is known as turning point (figure 1). Turning point is that point where the environment degradation is at its peak and after that it shows a downfall with further increase in real per capita GDP.



The environmental Kuznets curve is bell shape. The reason of bell shaped curve is that as the countries initiate industrialization little attention is given to environmental resources, which leads to increase in environmental degradation. After that when industry production system attains some standard and environmental pollution is at its peak then attention changes from self interest to social welfare.

Researcher Panayotou (2003) has mention 3 reasons for inversion of environmental pollution.

i. The turning point occurs because of more affluent and progressive communities taking place. That focuses more on clean environment.

ii. When industrialization begins, the scale effect will take place, focus is on maximizing output and pollution increases. Further firms switch to composition effect and it levels the rate of pollution. Finally, technology effect will take place, which reduces pollution

iii. Structural change is also a cause of up and down of EKC. When a country has enough mature companies or industrialization has taken place. Then service sector get prominence, which will further reduce pollution.

1.5 India and trends of Environment

- **Air pollution**

According to Ministry of Environment and Forest (MOEF, 2009) in the world 3 million premature deaths occurs each year due to indoor and outdoor air pollution, out of which highest number asses to occur in India.

The report shows that population growth, vehicular emission, urbanization, industrial sector growth, power sector (use of coal), agriculture waste burning and domestic sector (indoor air pollution) are causes of air quality.

There are nearly 17 cities which produce more of air pollution. They are Delhi, Patna, Hyderabad, Ahmedabad, Faridabad, Puna, Agra, Chennai, Kanpur, Mumbai, Bangalore, Jharia, Jodhpur, Lucknow, Kolkata, Varanasi and Sholapur.

- **Water pollution**

According to MOEF (2009) the heavy use of fertilizers and pesticides in agriculture sector is cause of ground water pollution.

According to MOWR (2000) the industrial sector generates 55000 million cubic meters wastewater per day, of which 68.5 million cubic meters are dumped directly into local rivers.

According to MOEF (2009) the domestic sector produce over 7,267 million liter of wastewater per day.

- **Land degradation**

According to MOEF (2009) intensive farming activity has contributed to soil erosion, land salivation, loss of nutrients. Even the introduction of green revolution in the country has lead to over exploitation of land, water resources.

The burning of wheat and rice straw instead of recycling causes rises in temperature of soil and change the carbon and nitrogen equilibrium. This leads to a loss of .824 million tones of nitrogen, phosphors, and potassium from the soil.

According to report between 2003 and 2005, the total forest cover has been decreased slightly by 728 squares Km in India. The deforestation leads to soil erosion, floods, and landslides.

1.6 Chapterisation

The Thesis has been organised into the following five Chapters.

Chapter 1

Chapter-I covers an Overview of Economic Growth and Environment Kuznet's Curve in India. The chapter describes the Natural Environment and its resources. It also exposes the Pollutants and Its Types. Then after explaining the Environmental Kuznet's Curve in India, it covers the trends of Environment. The last section describes the chapter scheme.

Chapter II

Chapter II, discusses the review of literature on Environment Kuznet's Curve and its implications on India. The review helps to know emphasis and direction of research being done, the time periods of the studies, the scope and limitations of studies conducted, the methodology adopted for measuring productivity indices, the conclusions drawn from these studies the objectives fulfilled and the benefits accrued. An attempt has also been made to summarize the review of studies on Environment Kuznet's Curve .

Chapter III

In the subsequent chapter III, model and methodology has been discussed. This chapter outlines the objectives of the study. It also explains the hypotheses proposed for the study. This chapter also discusses the data sources of the present study. Finally the chapter explains the methodology adopted to achieve the objectives of the study.

Chapter IV

Chapter IV outlines the state wise environmental status, the level of pollution present in the states. The analysis shifts to find out whether environmental Kuznet's curve is prevalent in different states.

Chapter V

Finally, chapter V covers the conclusion of the study and major findings. The chapter also explains the limitations of the study and identifies the future areas of research.

CHAPTER II

REVIEW OF LITERATURE

2.1 Review of literature is must for having a deeper analysis of the topic. It also exposes one to the research done in the field and helps in giving direction to the area of research to be covered. Section 2.1 provides an outline of the chapter. Section 2.2 provides the detailed review. Finally section 2.3 summarizes the review of studies on Environment Kuznet's curve.

2.2 Review of Literature

The study by Barua and Hubacek (January 2008) examined relationship between economic growth and water pollution for 16 states of India. The study has been done to investigate whether an environmental Kuznets curve exist for water pollution, with the increase in the state per capita income. In this study, Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) have been taken as water quality indicators. The result showed that out of 16 states, 4 states did not show any relationship between water pollution and economic growth whereas 4 states follows inverted "U" shape curve, 6 states follow N-shape curve and 2 states follows U shape curve. The first turning point appears at Rs.5000 (US $100) per capita income level and second turning point appears at Rs. 15000 (US $320).

Feridun *et al.* (2006) analyse the implication of trade liberalization on environment in developing countries. The study concludes that the composition impact of free trade is positive on environment; the scale effect is very strong but negative on the environment and the technique effect of trade liberalization is small but negative on the environment. The result indicates negative impact of trade liberalization on the environment. In this study, ordinary least square (OLS) and general least square (GLS) methods are being utilized.

Kahn and Schwartz (July 2004) analyse over 24,000 California vehicles to estimate environmental Kuznets curve. According to the study, scale effect or quantity effect shows that rich people drive more miles than poor people and technique effect or quality effect shows that rich people own new and high quality vehicles. But the technique effect offsets the scale effect of driving and results in inverted “U” shape curve. Thus, this study indicates that as poorer people grow richer, the annual vehicle emission rises initially, but beyond an income turning point richer people pollute less than poorer people.

Connor *et al*. (July 2001) analysed 18 industrialized countries embodied pollution in trade from 1976 to 1994. The study shows that in last year of analysis, total import of Japan, USA and Western Europe has been increased and results in large air pollutant emissions than local exports. Their study shows that Japan and Western Europe shows an inverted-U shape curve whereas USA sows N-shape curve. In the time of analysis, Japanese and Europeans environmental terms of trade with developing country have been improved whereas American environmental terms of trade with the developing country tends to be deteriorated. Their study concludes that relationship between environment quality and terms of trade shows positive relationship. So this study result suggests that inter-country physical flows may be useful for sustainable development.

According to Suri and Chapman (July 1998) industrializing countries have higher growth rate as compared to industrialized countries. This study also show that industrialized countries have been able to reduce their energy requirements as compared to industrializing countries by importing manufactured goods. The study concludes that exports of manufactured goods by industrializing countries is the main factor for the upward sloping portion and import by industrialized countries contributed to the downward slope of environmental Kuznets curve.

According to Chaudhuri and Pfaff (2004) richer households consume more of cooking and heating services as compared to poorer households. But rich people use higher quality fuels which emits less of air pollutions whereas poorer households use high polluting vintage and maintain them less which emits more of pollution. The study concludes that poorer people pollute more as compared to richer peoples. This study has taken the case of Pakistan using household-level data measuring indoor air pollution emissions.

Cole and Neumayer (2004) examine link between population size, demographic factors (like urbanization and household size) and pollutants. These researchers have taken cross-nation data and have examined two air pollutants – sulfur dioxide and carbon dioxide. According to this study, carbon dioxide emission increases proportionately with increase in population. Higher urbanization and lower average household size will increase carbon emissions. For sulfur dioxide case, population-emission elasticity rises at higher population level. But urbanization and average household size does not seem to be significant determinant of sulfur dioxide emissions. This study concludes that the share of increasing global emission will be accounted by developing countries.

Mazzanti and Massimiliano *et al.* (2008) contribute new empirical evidence on delinking and Environmental Kuznets Curves (EKC) for greenhouse gases and other air pollutant emissions in Italy. A panel dataset based on the Italian NAMEA (National Accounts Matrix including Environmental Accounts) for 1990– 2001 is analysed. The highly disaggregated dataset (29 production branches, 12 years and nine air emissions) provides a large. Both value added and capital stock per employee are used as alternative drivers for analysing sectoral NAMEA emissions. Trade openness at the same sectoral level is also introduced among the covariates. The researchers find mixed evidence supporting the EKC hypothesis. The analysis of NAMEA-based data shows that some of the pollutants such as two greenhouse gases (CO2 and CH4) and CO, produce inverted U-shaped curves with coherent within range turning points. Other pollutants (SOX, NOX, PM10) show a monotonic or even N-shaped relationship. Macro sectoral disaggregated analysis highlights that the aggregated outcome should hide some heterogeneity across different groups of production branches (industry, manufacturing only and services). Services tend to present an inverted N-shape in most cases. Manufacturing industry shows a mix of inverted U and N-shapes, depending on the emission considered. The same is true for industry (all industries, not only manufacturing): although a turning point has been experienced, N-shapes may lead to increased emissions with respect to very high levels of the economic driver. In general, EKC evidence is more pronounced for greenhouse gases. The study concludes that analysis at macro sector (whole industry, manufacturing only and services) can be the most promising approach to future research on EKC.

The study by Llorca and Matthieu *et al.* (2008) aims at estimating the Environmental Kuznets Curve (EKC) for the sulphur dioxide (SO2) emissions in a panel of 28 Chinese provinces. First, using a fixed effects model, econometric findings reveal an N shape EKC with a turning point of 4500 yuans (index 1990). A Chow test reveals a break in 1995, so that the estimation of the model indicates an increasing linear relationship between GDP per capita and SO2 emissions. The study analyses the previous results which imply that the decrease of the Chinese sulphur dioxide emissions during 1996–1999 did not result from the EKC but from an exogenous public action.

Sobhee and Sanjeev K. (2004), argues that the environmental Kuznets curve (EKC) can be shaped as a logistic curve rather than a mere quadratic equation. Instead of being modeled as a polynomial of degree two, the EKC can be characterized by a polynomial of degree three. The inverted-U shape remains. However, in the proposed specification, what matters, is the rate at which total environmental degradation (TED) occurs, that is, marginal environmental degradation (MED). When TED is quadratic, MED is linearly represented with respect to per capita output. This is considered to be inconsistent with real-life situations, and instead a quadratic MED is postulated, from which a logistic EKC is derived. Prior to a given income threshold, MED rises, attains a maximum at the threshold, and falls ultimately beyond it. This formulation of the EKC conforms to the probabilistic econometric models usually applied in environmental studies.

Janssen and Marco *et al.* (2004) explores that the most important environmental problems can be related to materials flows through the economy. Regional and national economies use materials that are either extracted domestically or imported from other regions. Therefore, an analysis of optimal patterns of combined economic development and materials use requires that both trade and environmental aspects are taken into account. The study provides a model that optimises longterm welfare for two regions that trade in virgin and recycled materials as well as consumer goods. The regions differ in one respect, namely with regard to domestic availability of a material resource. Analysis of the model shows, among other things, that the relationship between production and virgin material use can follow an Environmental Kuznets curves or an N-shaped curve. The latter points at ‘‘re-linking’’ of income growth and material resource use.

Although trade of material resources and goods increases the carrying capacity of both regions, and in turn their levels of welfare, it can not prevent the re-linking phenomenon.

The study by Archibald and Sandra *et al.* (2009) examines the effects of political, structural and economic changes on environmental quality in 25 Central and East European countries (CEECs) and the countries of the Commonwealth of Independent States (CIS) using selected water pollution indicators and by testing the environmental Kuznets curve (EKC). Despite substantial research on the transition effects from centrally planned economies and totalitarian political systems to democracy and free market economies, the literature is limited with respect to the short- and long-term environmental impacts. Considering the institutional and structural changes in these economies, rising per capita income and increased trade and investment openness, these countries can be characterized as early, late and non-liberalizers with respect to the start and continuation of liberalization processes – a critical element of the systemic transformation in the CEECs. While trends in selected economic and social indicators show that early liberalizers enjoyed positive gains relative to late liberalizers, the selected environmental indicators do not indicate consistent trends with regard to surface water quality. Among early and late liberalizers, nitrate, orthophosphate and ammonium concentrations decline and converge over time. Phosphorus concentrations initially dropped but then increased again for both groups of countries. Using the indicator of biological oxygen demand (BOD) as the dependent variable and a set of structural and economic measures as the independent variables, our econometric regression model provides some evidence for the EKC hypothesis and estimates the per capita income turning point for industrial BOD effluents to be approximately 3800–5000 USD.

Jain and Chandhuri (2009) tried to examine the hypothesis of Environmental Kuznets Curve. By using time series data from 1990 to 2005 across countries, these researchers concluded that least developed to developing countries like India and China are on the rising part of the inverted U-curve i.e. increasing environment pollution. Whereas, developing to developed countries like UK and Germany are on the falling part of the inverted U-curve i.e. decreasing environment pollution. On the other hand, developed countries like USA and Canada are on the rising part of the N-curve i.e. increasing environment pollution. This indicates that both the inverted U-curve and N-curve are useful tools of analysis and can be used as indicators of economic development.

2.3: Summary results of Literature Review

Author	**About the study**	**Major contributions**
Suri and Chapman (July1998)	-Comparison between industrialized countries and industrializing countries	-exports of manufactured goods by industrializing countries is the main factor for the upward sloping portion and import by industrialized countries contributed to the downward slope of environmental Kuznets curve
Sobhee and Sanjeev K. (2004)		-the EKC conforms to the probabilistic econometric models usually applied in environmental studies.
Llorca and Matthieu (2008)	-1996–1999 -Panel data	-the decrease of the Chinese sulphur dioxide emissions did not result from the EKC -the model indicates an increasing linear relationship between GDP per capita and SO2 emissions
Mazzanti and Massimiliano (2008)	-panel data -1990– 2001	- CO2 and CH4 and CO, show inverted U-shaped curves - SOX, NOX, PM10 show N-shaped relationship. - Services tend to present an inverted N-shape in most cases. - Manufacturing industry shows a mix of inverted U and N-shape
Cole and Neumayer (2004)	- cross-nation data -two air pollutants (sulfur dioxide and carbon dioxide)	- carbon dioxide emission increases with increase in population -Higher urbanization and lower average household size will increase carbon emissions. -Sulfur dioxide , population-emission elasticity rises at higher population level.
Connor *et al*. (July 2001)	-18industrialized countries analysed -1976 to 1994.	- Import results in large air pollutant emissions than local exports - Japan and Western Europe shows an inverted-U shape curve - USA shows N-shape curve - relationship between environment quality and terms of trade shows positive relationship

Author	About the study	Major contributions
Chaudhuri and Pfaff (2004)	-case of Pakistan - household- level data -measuring indoor air pollution emissions.	-Rich households consume more of cooking and use higher quality fuels which emits less of air pollutions - poorer people pollute more as compared to richer peoples.
Kahn and Schwartz (July 2004)	-analyse over 24,000 California vehicles	- rich people drive more miles and own high quality vehicles. - as poorer people grow richer, the annual vehicle emission rises initially, but beyond an income turning point richer people pollute less than poorer people
Feridun *et al.* (2006)	-ordinary least square (OLS) and general least square (GLS) methods are being utilized. - the implication of trade liberalization on environment	-the composition impact of free trade is positive on environment; -the scale effect is very strong but negative on the environment -the technique effect of trade liberalization is small but negative on the environment
Janssen and Marco (2004)		-the relationship between production and virgin material use can follow an Environmental Kuznets curves or an N-shaped curve.
Archibald and Sandra (2009)	- The effects of political, structural and economic changes on environmental quality (BOD).	- Among early and late liberalizers, nitrate, orthophosphate and ammonium concentrations decline. - Phosphorus concentrations initially dropped but then increased again for both groups of countries
Barua and Hubacek (January 2008)	-16 states of India -Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)	-4 states did not show any relationship between water pollution and economic growth -4 states follows inverted "U" shape curve, -6 states follow N-shape curve -2 states follows U shape curve
Jain and Chandhuri (2009)	- time series data from 1990 to 2005 - across countries	- least developed to developing countries are on the rising part of the inverted U-curve. - developing to developed countries are on the falling part of the inverted U-curve. - developed countries are on the rising part of the N-curve

CHAPER III

RESEARCH DESIGN AND METHODOLOGY

In this chapter the model and methodology has been discussed. The chapter is divided into five sections. Section 3.1 describes the objectives of the study. Section 3.2 explains the hypotheses proposed for the study. Section 3.3 deals with the data sources and section 3.4 discusses the methodology used in the present study.

3.1 Objectives of the Study

The study has been undertaken with the following broad objectives:

1. To find out whether relationship between Net State Domestic Production and environment degradation is "inverted U" shaped or not.
2. To find out the relation between Oxides of Nitrogen (NOx) emission and NSDP.
3. To find out the relationship between have Sulphur dioxide (SO2) and NSDP.
4. To find out the relationship between Respirable Suspended Particulate Matter (RSPM) and NSDP.
5. To find out the relationship between Suspended Particulate Matter (SPM) and NSDP.

3.2 Hypotheses

The hypotheses proposed for the study are**:**

H_1: States having higher economic growth may report higher Oxides of Nitrogen (NO_x) emission.

H_2: States having higher economic growth may have Sulphur dioxide (SO2) emission.

H_3: States having higher economic growth may have Sulphur dioxide (SO2) emission.

H_4: States having higher economic growth may possess higher Respirable Suspended Particulate Matter (RSPM).

H5: States having higher economic growth may possess higher Suspended Particulate Matter (SPM).

H_6: All pollutants like Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur dioxide (SO2), Oxides of Nitrogen (NOx) follow environmental kuznets curve or forms inverted U-shape curve.

3.3 Data Sources

The study is based on secondary data. Data will be collected through Indiastat database. The other sources of data are: Reserve Bank of India Bulletin, Hand Book of Statistics; State Pollution Boards, Economic Surveys, Central Pollution Control Board (CPCB), Ministry Of Environment and Forest (Government of India); Nation Ambient Air Quality Monitoring (NAAQM). This study analysis 4 pollutants Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur dioxide (SO2), Oxides of Nitrogen (NOx), and data taken from 2004 to 2008.

3.4 Research Methodology

- Annual Average Concentration of Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur dioxide (SO2), Oxides of Nitrogen (NOx), shall be calculated.
- Inter period comparison of Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur dioxide (SO2), Oxides of Nitrogen (NOx) related to Net State Domestic Production of the Indian Economy.
- Comparing the result with the definition of Environmental Kuznets Curve and, thus, arriving at a conclusion.

In this economic growth is taken as Net State Domestic Production of state wise. The industrial and residential annual average concentration of 4 pollutants are taken together.

CHAPTER IV

DATA ANALYSIS AND INTERPRETATION

Chapter IV outlines the state wise environmental status, the level of pollution present in the states. The analysis shifts to find out whether environmental Kuznet's curve is prevalent in different states. Section 4.1 gives State Domestic Product at Factor Cost State-Wise (At Constant Prices). Section 4.2 gives the detailed account of Sulphur Dioxide levels. This section presents the Environmental Kuznets Curve for Developed states for SO_2 Emissions. Section 4.3 gives the levels of Oxides of Nitrogen especially Nitrogen dioxide (NO2). Then this section presents the Environmental Kuznets Curve for Developed states: NO_2 Emission. Section 4.4 presents the details of the Particulate Matter. Particulate matter is a mixture of many subclasses of pollutants that contain many different chemical species. Section 4.5 covers the SPM Emissions.

4.1 State-Wise Net State Domestic Product

Table 4.1: Net State Domestic Product at Factor Cost State-Wise (At Constant Prices)

Year	Andhra Pradesh	Assam	Bihar	Goa	Gujarat
2004	149067	39207	60045	6225	118525
2005	157975	41103	60579	6891	125599
2006	171462	43782	74831	7694	139265
2007	185462	46433	80998	8498	149933
2008	205486	49226	90566	9444	155667

Year	Chandigarh	Chhattisgarh	Delhi	Haryana	Himachal Pradesh
2004	5804	31377	62694	69988	15596
2005	6397	33356	69479	76304	17099
2006	7142	36176	77389	87944	18176
2007	7986	39340	89309	95499	19308
2008	9035	42087	100877	103236	20990

Year	Jharkhand	Karnataka	Kerala	Maharashtra	Meghalaya
2004	36886	109808	75467	250989	3993
2005	37706	122697	82575	272860	4270
2006	42139	130018	90244	298759	4548
2007	45922	144527	100427	327599	4800
2008	49595	151937	111059	357402	5060

Year	Manipur	Madhya Pradesh	Orissa	Punjab	Rajasthan	Tamil Nadu
2004	3240	75400	51086	72587	90445	147994
2005	3540	77874	54051	75471	96069	165953
2006	3668	82830	60746	81060	103616	185310
2007	3866	86425	63899	86400	111070	194099
2008	4000	90786	67821	92795	117423	203485

Year	Uttar Pradesh	West Bengal	Mizoram	Nagaland	Pondicherry	
2004	185920	152384	1839	3677	4125	
2005	195661	162491	1858	4053	3633	
2006	210044	171482	1967	4304	3864	
2007	225413	186569	2073	4566	4164	
2008	240039	201296	2205	-	4512	

4.2) Sulphur dioxide

SO_2, is formed when fuel containing sulphur is burned. Sulphur is prevalent in raw materials such as crude oil, coal, and ore that contains common metals like aluminium, copper, zinc, lead etc. SO_2 reacts with other gases in the atmosphere to form sulphates that can cause harm to human health. Effects of SO_2 include respiratory illness, visibility impairment, acid rain and aesthetic damage. Sulfur oxides are emitted in significant quantities from thermal power plants, and also from petroleum refining processes. The diesel driven vehicles are specific source of sulfur dioxide generated during combustion process.

Table 4.2: SO_2 levels (Annual Average Concentration in µg/m3) in various states since 2004-2006.

Year	Andhra Pradesh	Assam	Bihar	Goa	Gujarat
2004	7.92	4	12	BDL	18.93
2005	7.64	5.25	12.5	4	15
2006	7.25	6	10	BDL	18.57
2007	6.71	6.71	10	BDL	15.7
2008	6.45	6.45	7	BDL	14.74

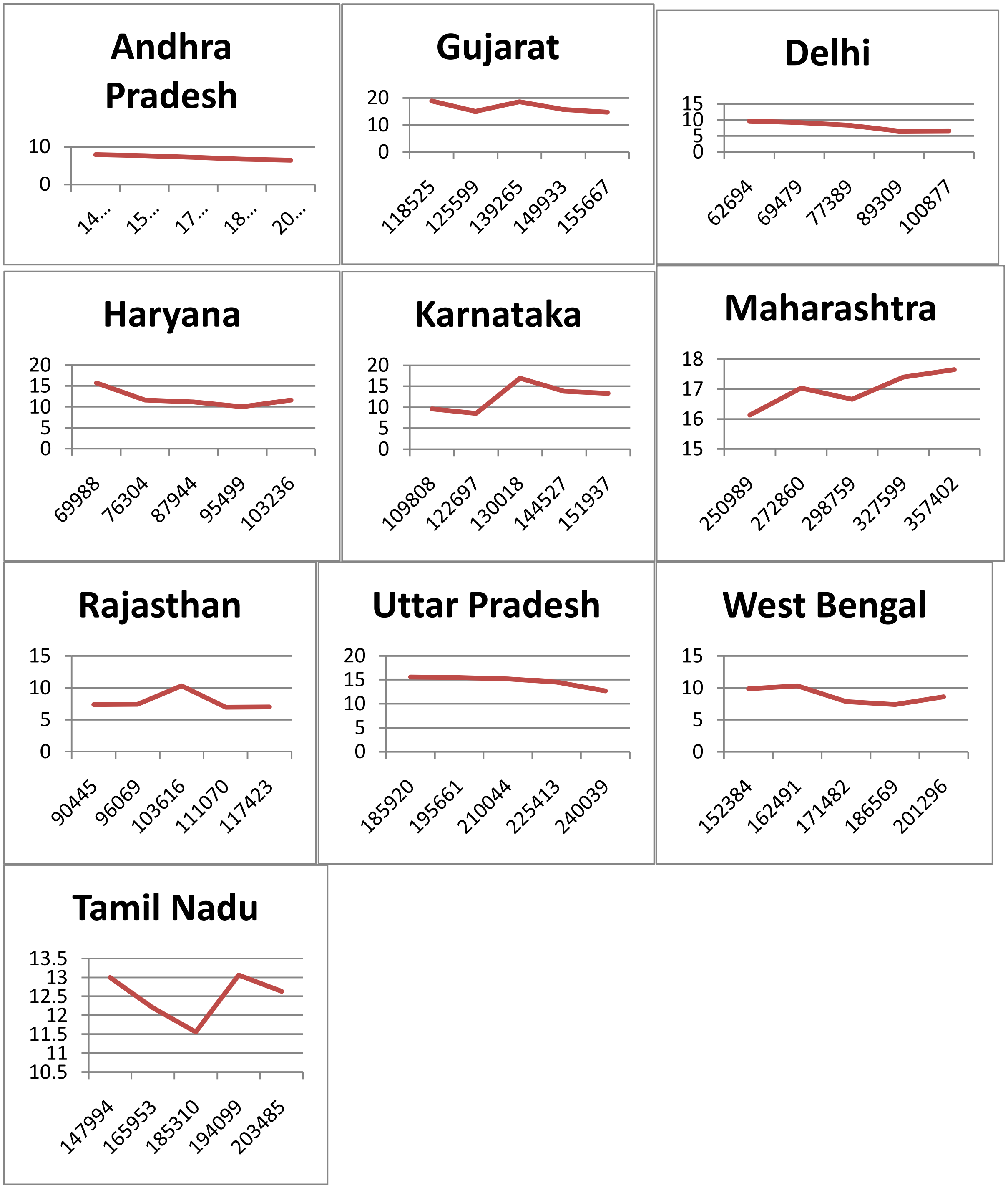
Year	Chandigarh	Chhattisgarh	Delhi	Haryana	Himachal Pradesh
2004	6	14.7	9.63	15.67	5
2005	BDL	15	9.11	11.6	6.33
2006	BDL	13.67	8.3	11.2	4.6
2007	BDL	14.78	6.44	10	4
2008	BDL	16.55	6.56	11.6	BDL

Year	Jharkhand	Karnataka	Kerala	Maharashtra	Meghalaya
2004	235	9.6	11.86	16.13	5
2005	24.83	8.53	10.22	17.03	BDL
2006	26.8	16.9	10	16.66	4
2007	26	13.8	8.22	17.4	4
2008	24.67	13.3	6.08	17.65	BDL

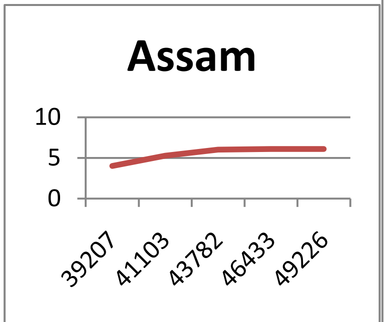
Year	Manipur	Madhya Pradesh	Orissa	Punjab	Rajasthan	Tamil Nadu
2004	BDL	13.7	4.75	14.75	7.39	13
2005	BDL	11.45	5.2	14.2	7.42	12.19
2006	BDL	12.72	6.67	12.3	10.31	11.56
2007	BDL	11.67	6.67	11.19	6.95	13.06
2008	BDL	11.89	7.43	10.53	7	12.63

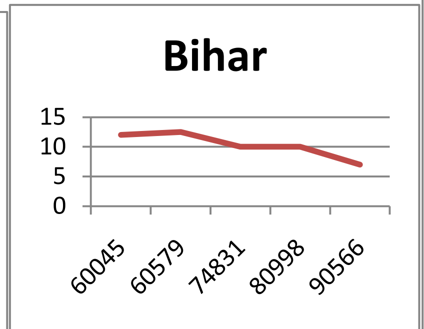
Year	Uttar Pradesh	West Bengal	Mizoram	Nagaland	Pondicherry	
2004	15.6	9.5	BDL	BDL	22.33	
2005	15.44	10.3	BDL	BDL	15.67	
2006	15.2	7.85	BDL	BDL	9.67	
2007	14.53	7.38	BDL	BDL	4.33	
2008	12.69	8.58	BDL	BDL	4.67	

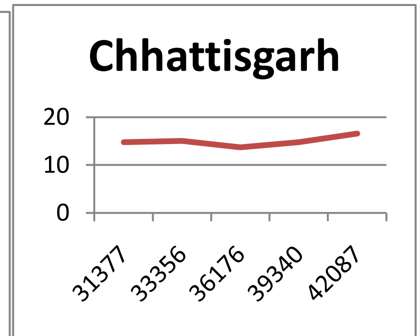
4.2.1 Environmental Kuznets Curve for Developed states: SO_2 Emissions

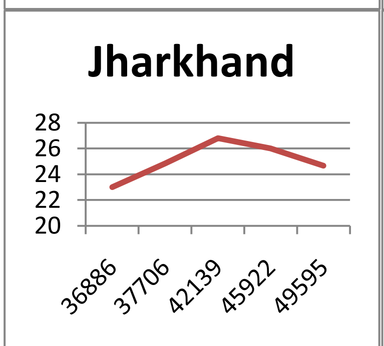


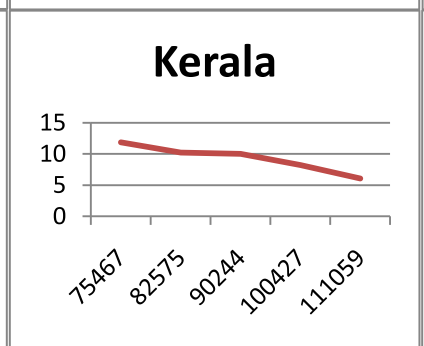
4.2.1 Environmental Kuznets Curve for Developing states: SO_2 Emissions

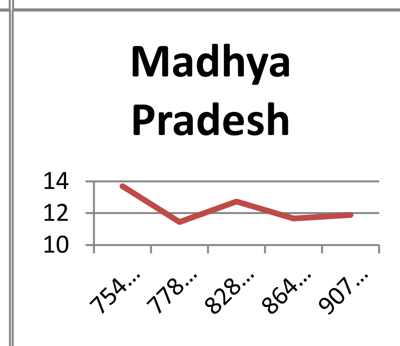


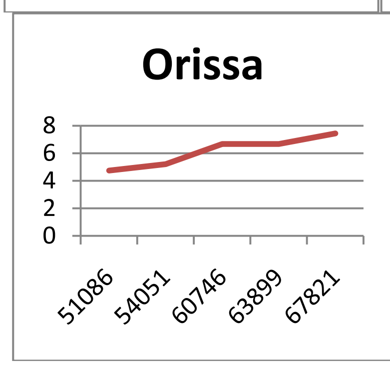


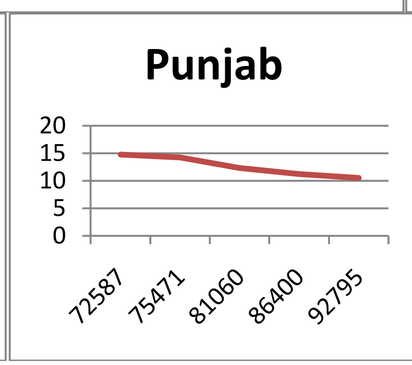


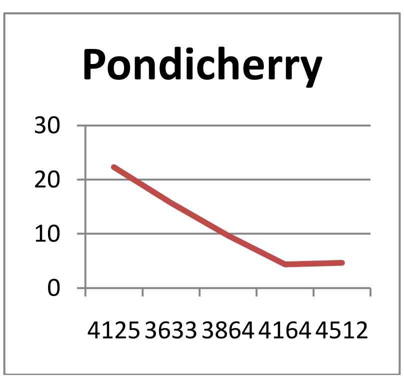












4.2.2 Top ten locations with respect to Sulphur Dioxide during 2008 in residential areas.

1	Maharashtra	Chandrapur	Gram Panchayat	40
2.	Uttar Pradesh	Khurja	Ahirpara	37
3.	Maharashtra	Nashik	NMC Building	33
4.	Tamil Nadu	Thoothukud	Fisheries College	32
5.	Tamil Nadu	Thoothukudi	AVM Jewellery Bldg.	29
6	Maharashtra	Chandrapur	Nagar Parishad	27
7.	Uttaranchal	Dehradun	Clock Tower	27
8.	Maharashtra	Nashik	RTO Colony Tank	26
9.	Maharashtra	Lote	Chalke Wadi	25
10.	Maharashtra	Pune	Swargate	22

4.2.3: Top ten locations with respect to Sulphur Dioxide during 2008 in industrial areas.

1	Uttar Pradesh	Khurja	CGCRI	42
2.	Maharashtra	Mumbai	MIDC	41
3.	Jharkhand	Jamshedpur	Bistupur Vehicle TC	38
4.	Maharashtra	Chandrapur	M.I.D.C.	37
5.	Jharkhand	Jamshedpur	Golmuri Vehical TC	36
6	Maharashtra	Mumbai	Municipal Council	35
7.	Maharashtra	Tarapur	Police Chowki	31
8.	Maharashtra	Tarapur	Sports Stadium	31
9.	Maharashtra	Nashik	VIP Industrial Area	30
10.	Madhya Pradesh	Nagda	Chem. D. Labour Club	30

4.3) Oxides of Nitrogen

Oxides of nitrogen is a generic term for a group of highly reactive gases that contain nitrogen and oxygen in varying amounts. Nitrogen dioxide (NO2) along with particulates is seen as a reddish brown layer over urban areas. Nitrogen oxides are formed when fuel is burned at high temperature. Sources of nitrogen oxides includes vehicles, industrial processes that burn fuel. They also contribute to nutrient overload that deteriorates water quality. Nitrogen dioxide irritates the nose and throat, and it appears to increase susceptibility to respiratory infections.

Table 4.3: NO2 levels (Annual Average Concentration in µg/m3) in various states since 2004-2006.

Year	Andhra Pradesh	Assam	Bihar	Goa	Gujarat
2004	30.92	14.5	26	10.33	28.53
2005	29.73	15.5	37.5	10	26.89
2006	26.9	14.11	41	10	25.7
2007	25.71	12.64	49.5	12	24.75
2008	25.38	13.18	39.5	18	22.74

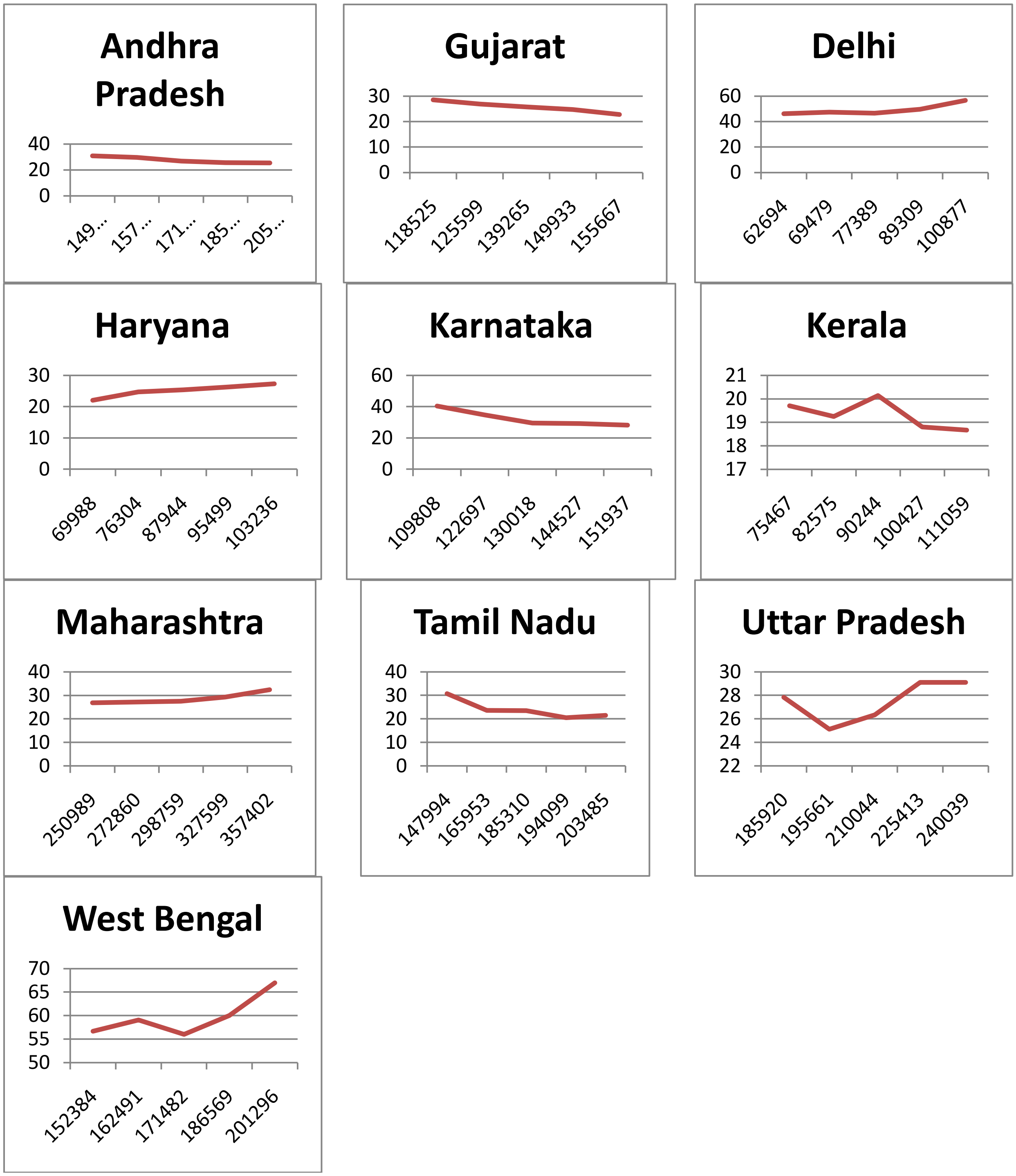
Year	Chandigarh	Chhattisgarh	Delhi	Haryana	Himachal Pradesh
2004	29.67	26.25	46.11	22	13.29
2005	15.4	27.44	47.33	24.67	18.29
2006	12.6	26.44	46.56	25.33	16.1
2007	14.8	26.89	49.67	26.33	13.89
2008	15	29.78	56.67	27.33	12.45

Year	Jharkhand	Karnataka	Kerala	Maharashtra	Meghalaya
2994	54.83	40.33	19.71	26.86	19
2005	46.16	34.75	19.25	27.13	12
2006	52.4	29.45	20.14	27.45	14.5
2007	49.83	29.09	18.8	29.3	14
2008	44.16	28.16	18.67	32.44	25

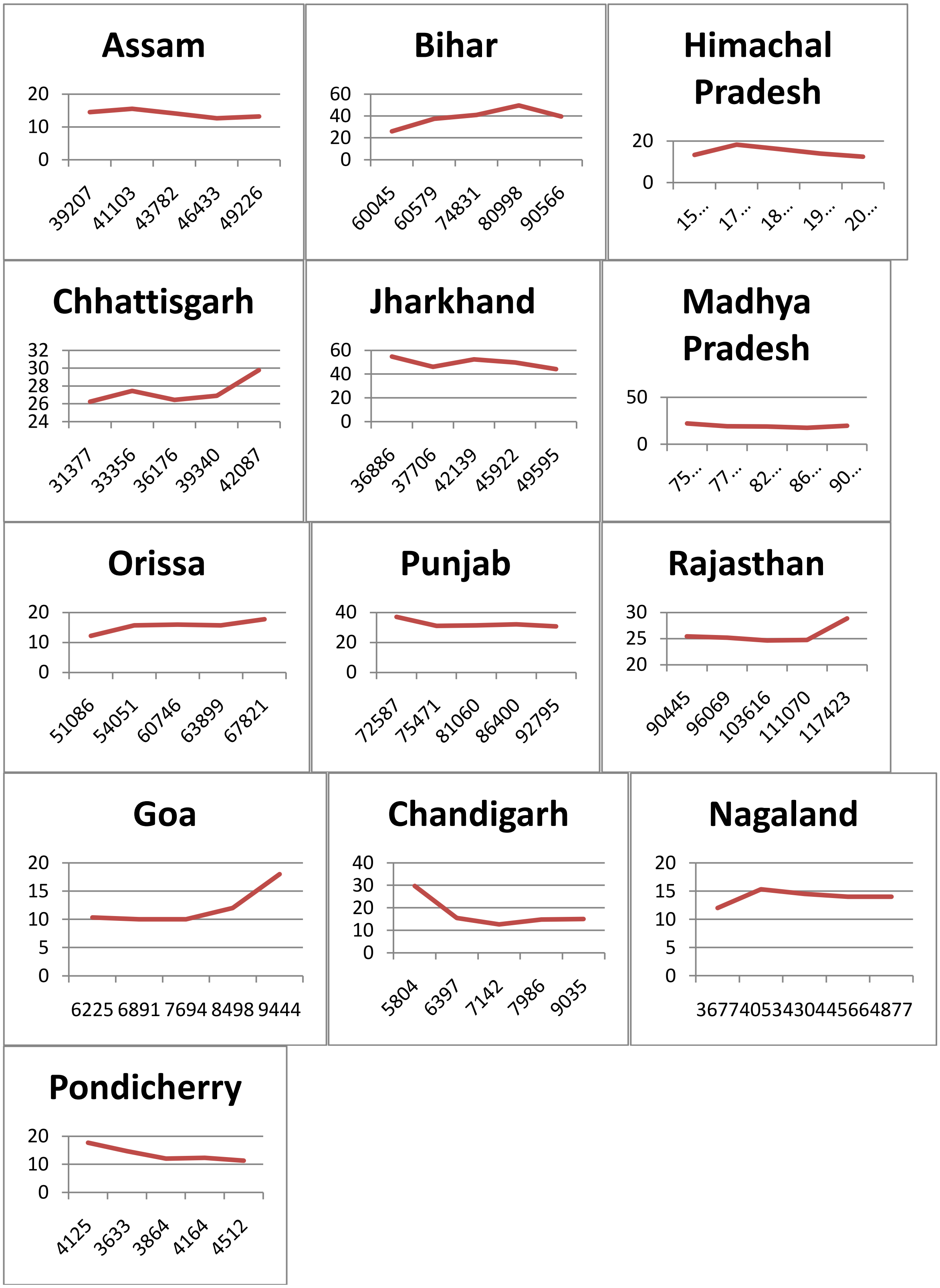
Year	Madhya Pradesh	Orissa	Punjab	Rajasthan	Tamil Nadu
2004	22.2	12.16	37	25.44	30.69
2005	19.09	15.69	31	25.2	23.59
2006	18.96	15.93	31.35	24.64	23.5
2007	17.55	15.69	32.1	24.76	20.5
2008	19.63	17.73	30.74	28.85	21.44

Year	Uttar Pradesh	West Bengal	Mizoram	Nagaland	Pondicherry
2004	27.84	56.67	BDL		17.66
2005	25.11	59.07	BDL	15.33	14.67
2006	26.34	56	10.5	14.5	12
2007	29.11	60	BDL	14	BDL
2008	29.11	67	BDL	14	11.33

4.3.2 Environmental Kuznets Curve for Developed states: NO_2 Emission



4.3.2 Environmental Kuznets Curve for developing states: NO_2 Emission



4.3.3 Top ten locations with respect to Nitrogen Dioxide during 2008 in residential areas.

1.	Delhi	Delhi	Town Hall	77*
2.	West Bengal	Kolkata	Moulali	76*
3.	West Bengal	Howrah	Naskarpara	73*
4.	Delhi	Delhi	N.Y. School	69*
5.	West Bengal	Kolkata	Lal Bazar	69*
6.	West Bengal	Kolkata	Minto Park	68*
7.	West Bengal	Kolkata	Salt Lake	64*
8.	West Bengal	Howrah	Bator	61*
9.	Maharashtra	Chandrapur SRO,	Bapat Nagar	60*
10.	West Bengal	Durgapur (WB)	PCBL Club	59

4.3.4 Top ten locations wrt Nitrogen Dioxide during 2008 in industrial areas

1.	West Bengal	Howrah	Bandhaghat	91*
2.	West Bengal	Durgapur (WB)	Dew India Ltd	82*
3.	West Bengal	Kolkata	Behala Chowrasta	75
4.	Delhi	Delhi	Mayapuri Indl. Area	75
5.	West Bengal	Durgapur (WB)	Kwality Hotel	74
6.	West Bengal	Asansol	Asansol M.C.	74
7.	West Bengal	Howrah	Howrah MC	74
8.	West Bengal	Kolkata	Cossipore Police Stn	65
9.	West Bengal	Kolkata	Dunlop Bridge	63
10	Delhi	Delhi	Shahdara	58

4. 4) Particulate Matter

Particulate matter is a mixture of many subclasses of pollutants that contain many different chemical species. PM10 are the particles with upper size limited by a 50% cut at 10 μm aerodynamic diameter (USEPA, 1996). PM10 can be formed by physical processes of crushing, grinding and abrasion of surfaces. Mining and agricultural activities are some of the sources of large size particles.PM2.5 are the particles with upper size limited by a 50% cut at 2.5 μm aerodynamic diameter (USEPA,1996).

Particulate matter is called primary if it is in the same form chemical form in which it is emitted into the atmosphere. The primary particulate matter includes windblown dust such as road dust, fly ash, soot etc. Particulate matter is called secondary it is formed by chemical reactions in the atmosphere. Secondary particulate matter include sulphates, nitrates etc.
The size of particles is directly linked to their potential for causing health problems.

Small particles less than 2.5 micrometers in diameter pose the greatest problems, because they can get deep into your lungs, and some may even get into your bloodstream. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing, decreased lung function; aggravated asthma; development of chronic bronchitis; irregular heartbeat; nonfatal heart attacks; and premature death in people with heart or lung disease. (USEPA,2008).

Table 4.4 RSPM levels (Annual Average Concentration in µg/m3) since 2004-2006.

Year	Andhra Pradesh	Assam	Bihar	Goa	Gujarat
2004	75.42	134.5	82	56	142.6
2005	79.6	112	108.5	10	52.89
2006	82.75	76.9	113	49.33	113.3
2007	80	74.63	123	48.67	95.3
2008	82.19	88.54	120	53.67	87.84

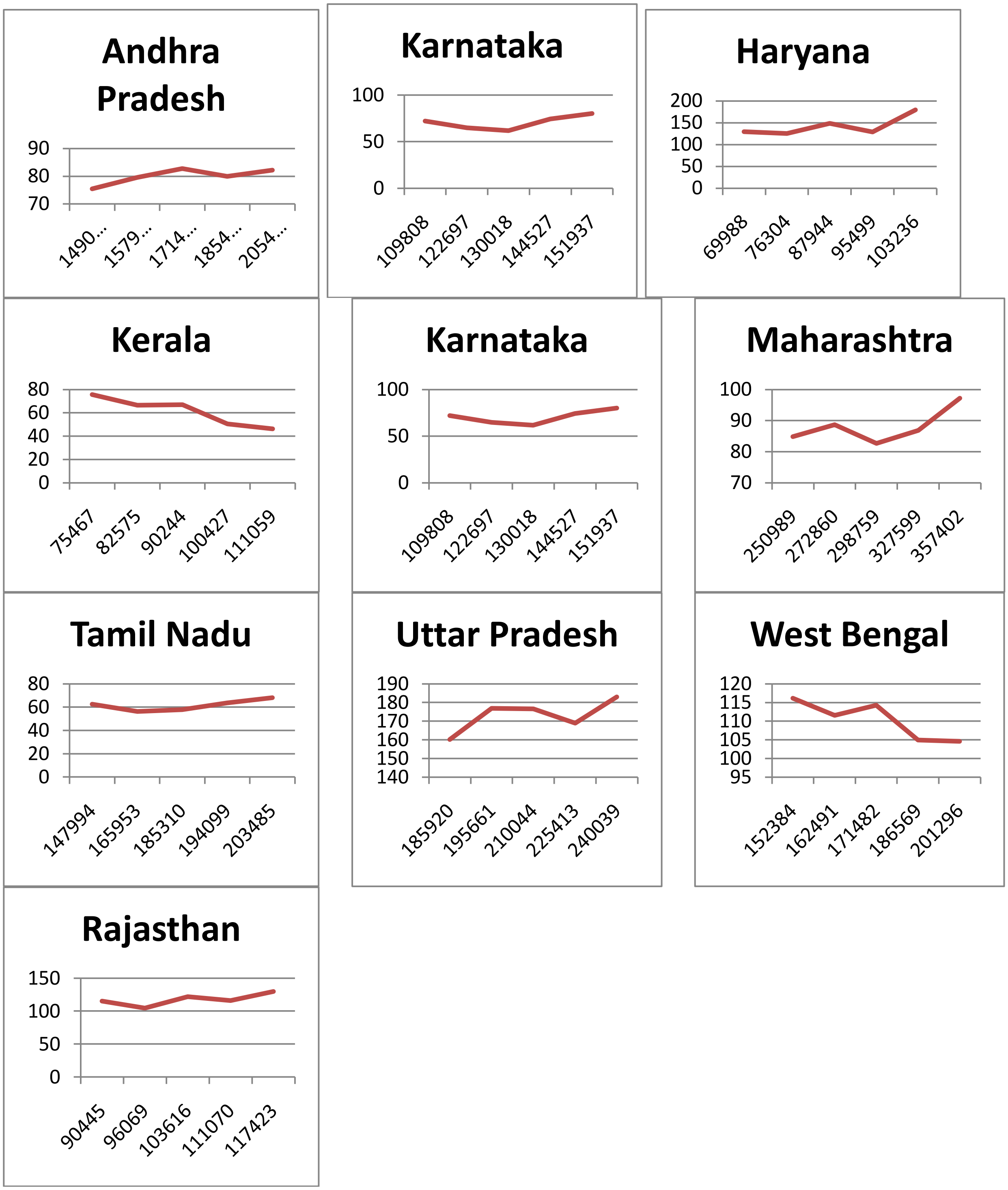
Year	Chandigarh	Chhattisgarh	Delhi	Haryana	Himachal Pradesh
2004	107.67	183.12	148.67	129.66	32.33
2005	95	138.11	114.44	125.6	30.67
2006	104.2	133.28	152.88	148.8	96.37
2007	100.6	118.44	146.55	128.8	108.09
2008	135.89	135.89	214.11	179.6	95.42

Year	Jharkhand	Karnataka	Kerala	Maharashtra	Meghalaya
2004	157.83	72.1	75.75	84.82	57
2005	133.33	64.85	66.54	88.72	59.5
2006	135.6	61.78	66.92	82.7	67.5
2007	147.16	74.37	50.42	86.85	66.5
2008	163.83	80	46.2	97.24	73

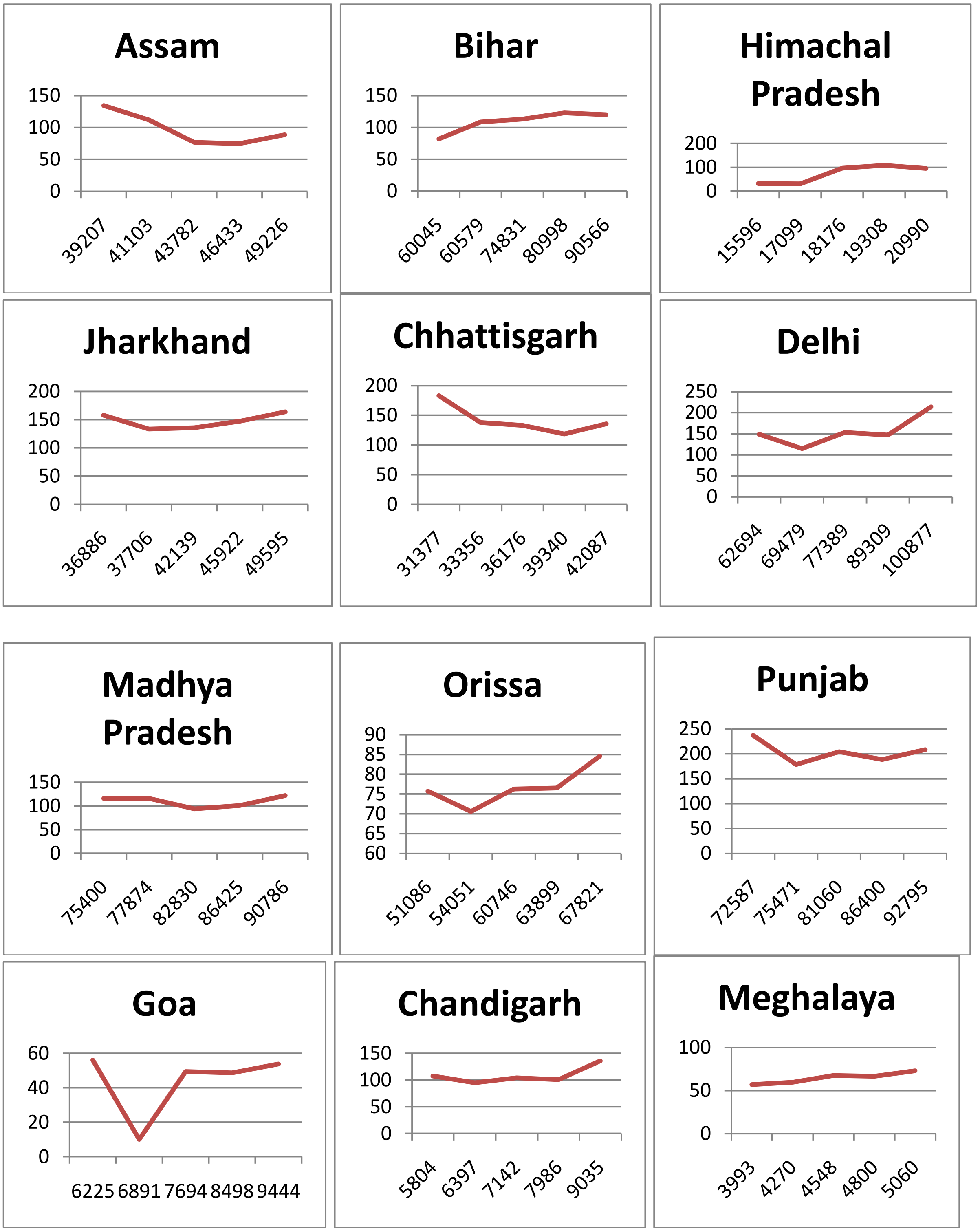
Year	Jharkhand	Karnataka	Kerala	Maharashtra	Meghalaya
2004	157.83	72.1	75.75	84.82	57
2005	133.33	64.85	66.54	88.72	59.5
2006	135.6	61.78	66.92	82.7	67.5
2007	147.16	74.37	50.42	86.85	66.5
2008	163.83	80	46.2	97.24	73

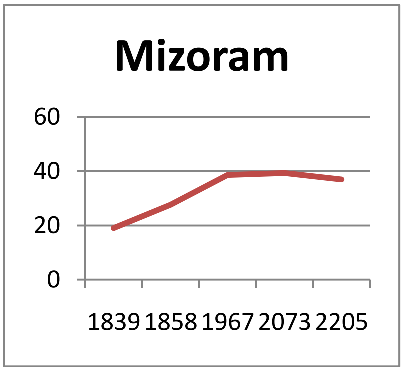
Year	Uttar Pradesh	West Bengal	Mizoram	Nagaland	Pondicherry
2004	160.19	116.15		69	50
2005	176.91	111.53	27.66	95.33	51
2006	176.63	114.3	38.66	73	65
2007	168.91	104.94	39.33	67.5	52.5
2008	183.05	104.57	37	71.5	49.5

4.4.1 Environmental Kuznets Curve for Developed states: RSPM Emission



4.4.1 Environmental Kuznets Curve for Developing states: RSPM Emission





Mizoram
60
40
20
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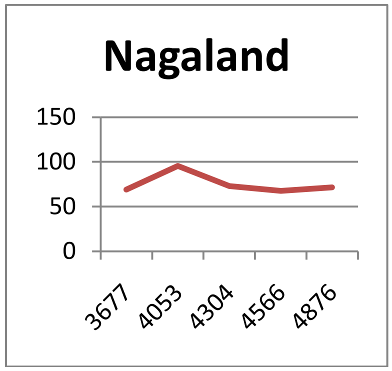
1839 1858 1967 2073 2205



Nagaland
150
100
50
0
3677
4053
4304
4566
4876

4.4.2 Top ten locations with respect to RSPM during 2008 in residential areas

1.	Delhi	Delhi	Town Hall	278
2.	Punjab	Ludhiana	PPCB Office Bldg.	263
3.	Punjab	Khanna	A S School	239
4.	Punjab	Ludhiana	Bharat Nagar Chowk	238
5.	Delhi	Delhi	Janakpuri	219
6.	Madhya Pradesh	Indore	Kothari Market	217
7.	Uttar Pradesh	Khurja	Ahirpara	217
8.	Punjab	Gobindgarh	United Rolling Mills	216
9.	Uttar Pradesh	Firozabad	Raza Ka Tal	215
10	Uttar Pradesh	Kanpur	Deputy Ka Parao	215

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4.4.2 Top ten locations with respect to RSPM during 2008 in industrial areas

1.	Punjab	Ludhiana	Rita Sewing Machines	351
2.	Madhya Pradesh	Satna	Sub-Divisional Off.	265
3.	Delhi	Delhi	Mayapuri Indl. Area	263
4.	Uttar Pradesh	Ghaziabad	Bulandshahar R.I.A.	257
5.	Punjab	Khanna	Markfed Vanaspati	255
6.	Uttar Pradesh	Khurja	CGCRI	245
7.	Madhya Pradesh	Indore	M.P. Laghu Udyog	240
8.	Uttar Pradesh	Firozabad	CDGI	239
9.	Rajasthan	Jaipur	VKIA	238
10	H.P	KalaAmb	Industrial Area	234

(4.4.3) Composition of Particulate Matter

The major constituents of RSPM are organic and elemental carbon, metals/elements like silicon, magnesium, iron, ions like sulphates, nitrates, ammonium etc. Understanding composition of particulate matter is most important to gain insight into the health effects caused and sources to be controlled.

(i) Elemental Carbon

Elemental carbon (EC), also called ‘‘black carbon’’ or ‘‘graphitic carbon’’, has a chemical structure similar to impure graphite. Atmospheric elemental carbon is from primary anthropogenic sources. EC plays an important role in atmospheric chemistry because of its adsorptive and catalytic properties, which can capture other pollutants to react on its surface.

(ii) Organic Carbon

Organic carbon (OC), a mixture of hydrocarbons and oxygenates. Organic carbon may be emitted as primary particles directly from sources, but secondary organics can also be formed in the atmosphere from the low vapor pressure products of atmospheric chemical reactions. OC is a complex mixture of thousands of different organic compounds, containing polycyclic aromatic hydrocarbons and other components.

(iii) Elements/Metals

Calcium, aluminum, silicon, magnesium, and iron are some of the crustal material
Most of the elements are emitted from coal, oil combustion, vehicles, industrial processes. Other sources include from road dust, tyre wear, construction activities etc.

(iv) Ions

The common ions found in particulate matter are sodium, sulphates, nitrates, calcium, chloride, potassium. Potassium and nitrate may be found in both the small size and coarse particles. Potassium comes from soil in coarse particles and in small size particles it comes from wood burning. Nitrate in formed by reaction of nitric acid with gas-phase ammonia forming particulate ammonium nitrate.

d) Carbon Monoxide (CO)

Carbon monoxide is a colorless, odorless and poisonous gas. It is formed by incomplete combustion of carbon containing fuels. Major source of CO are vehicles. Incomplete combustion is most likely to occur at low air-to-fuel ratios in the engine.CO enters the bloodstream through lungs and forms carboxyhemoglobin which inhibits blood's oxygen carrying capacity to organs and tissues. Persons with heart disease are especially sensitive to carbon monoxide poisoning and may experience chest pain if they breathe the gas while exercising.

e) Ozone

Ozone is a secondary pollutants formed in the atmosphere by reaction between oxides of nitrogen and volatile organic compounds (VOCs) in the presence of sunlight. Vehicles, industrial emissions, gasoline vapours, chemical solvents emit oxides of nitrogen and VOCs that form ozone. Peak O3 levels occur typically during the warmer times of the year.

f) Ammonia

Ammonia occurs naturally and is produced by human activity. Ammonia and ammonium salts are also found in small quantities in rainwater. It is an important source of nitrogen which is needed by plants and animals. Ammonia gas can be dissolved in water and is called liquid ammonia. No health effects have been found in humans exposed to typical environmental concentrations of ammonia. Exposure to high levels of ammonia in air may be irritating to skin, eyes, throat, and lungs and cause coughing and burns. Lung damage and death may occur after exposure to very high concentrations of ammonia.

g) Hazardous Air Pollutants

Hazardous air pollutants are also known as toxic air pollutants which may cause cancer or other serious health effects such as reproductive effects etc. Toxic air pollutants include benzene, perchlorethlyene, methylene chloride, dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds. Some toxic air pollutants such as mercury can deposit onto soils or surface waters, where they are taken up by plants and ingested by animals and are eventually magnified up through the food chain.

Table 4.5 SPM levels (Annual Average Concentration in µg/m3) in various states since 2004-2006.

Year	Andhra Pradesh	Assam	Bihar	Goa	Gujarat
2004	180.21	198.5	208.5	154.33	211.53
2005	195.47	157.5	278	150.33	229.47
2006	195.4	130.6	298	114	206.4
2007	202.05	123	311.5	113.66	201.65
2008	205.9	137.82	307.5	103	189.84

Year	Chandigarh	Chhattisgarh	Delhi	Haryana	Himachal Pradesh
2004	252.67	258.38	373.89	305.33	190
2005	228.4	239.78	357.89	271.2	177.67
2006	219	217.55	400.22	280.8	237.27
2007	217.2	219	381.11	246.8	192.72
2008	187.8	264.89	432.67	296.6	193.71

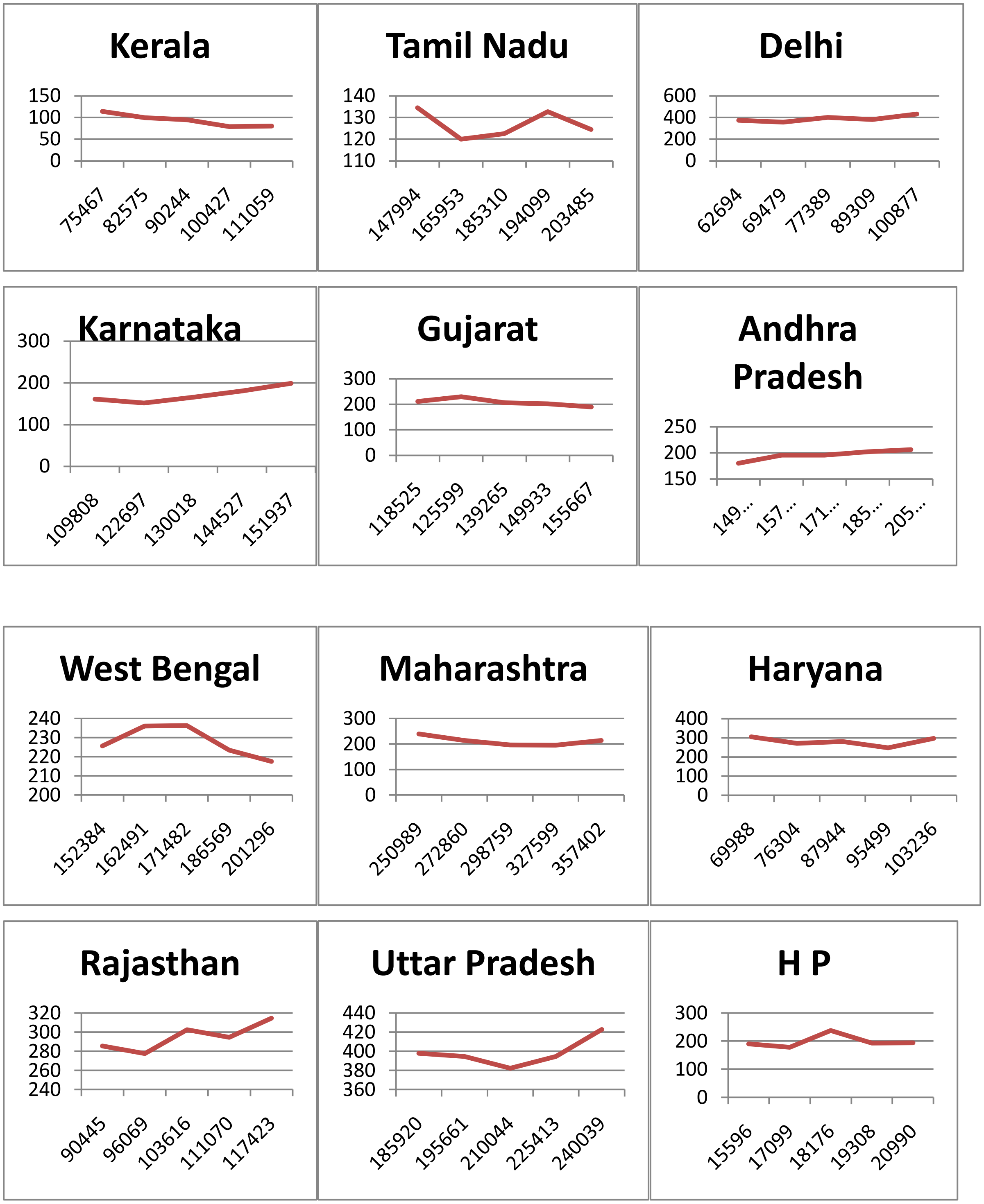
Year	Jharkhand	Karnataka	Kerala	Maharashtra	Meghalaya
2004	376.17	161.4	113.8	238.75	70
2005	261.17	152.14	99.58	213.95	76
2006	221.2	165.42	94.91	196.47	88
2007	249.16	180.93	79.13	195.05	132
2008	259.33	198.85	80.43	213.82	91

Year	Madhya Pradesh	Orissa	Punjab	Rajasthan	Tamil Nadu
2004	218.83	146.38		285.44	134.5
2005	206.5	147.38	192.5	277.57	120.06
2006	189.48	162.2	274.14	302.47	122.5
2007	219.45	166.69	287.5	294.38	132.75
2008	247.33	181.73	285.16	314.3	124.52

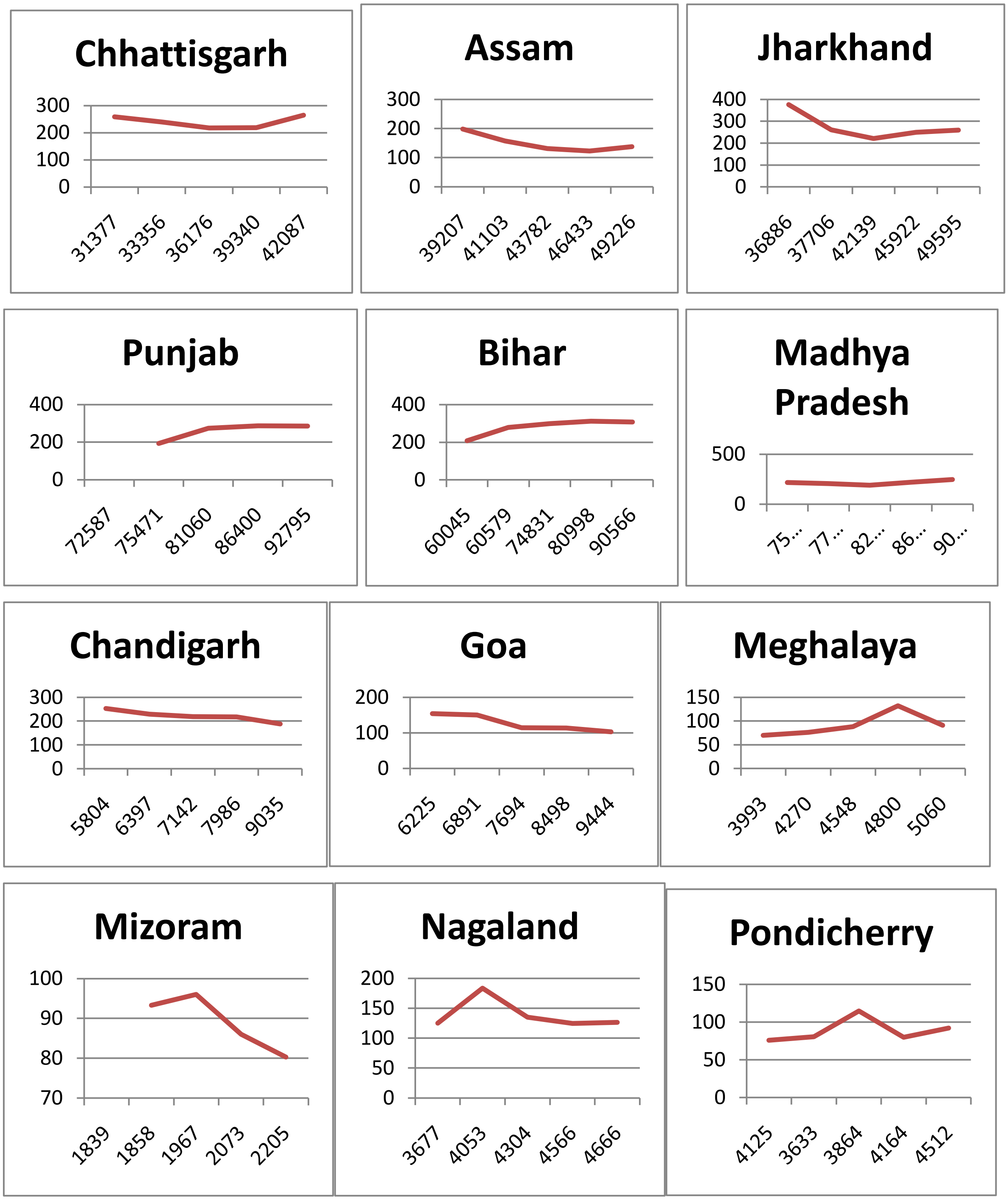
Year	Uttar Pradesh	West Bengal	Mizoram	Nagaland	Pondicherry
2004	397.88	225.54		125	76
2005	394.52	235.92	93.33	183.33	80.33
2006	382.2	236.26	96	135	114.66
2007	394.62	223.42	86	124.5	79.67
2008	422.75	217.5	80.33	126.5	92

4.5 SPM Emissions

4.5.1 Environmental Kuznets Curve for Developed states: SPM Emission



4.5.1 Environmental Kuznets Curve for Developing states: SPM Emission



4.5.2 Top ten locations with respect to SPM during 2008 in residential areas

1.	Uttar Pradesh	Meerut Begum	Bridge	709
2.	Uttar Pradesh	Meerut	Thana Railway Road	515
3.	Delhi	Delhi	Town Hall	508
4.	Uttar Pradesh	Kanpur	Deputy Ka Parao	483
5.	Uttar Pradesh	Khurja	Ahirpara	472
6.	Uttar Pradesh	Kanpur	Dabauli	470
7.	Uttar Pradesh	Firozabad	Raza Ka Tal	464
8.	Uttar Pradesh	Kanpur	Kidwai nagar	464
9.	Uttar Pradesh	Noida	R.O, UPPB	449
10.	Rajasthan	Jodhpur	Sojati Gate	437

4.5.2 Top ten locations with respect to SPM during 2008 in industrial areas

1.	Delhi	Delhi	Mayapuri Indl. Area	**529**
2.	Uttar Pradesh	Firozabad	CDGI	515
3.	Uttar Pradesh	Kanpur	Fazal Ganj	496
4.	Uttar Pradesh	Khurja	CGCRI	493
5.	Uttar Pradesh	Kanpur	Jajmau	471
6.	Delhi	Delhi	Shahzada Bagh	460
7.	Delhi	Delhi	Shahdara	459
8.	Uttar Pradesh	Ghaziabad	Bulandshahar	456
9	Haryana	Yamunanagar	Ballarpur Industries	430
10	Uttar Pradesh	Lucknow	Talkatora	429

Air (Prevention and Control of Pollution) Act 1981

Government of India enacted the Air (Prevention and Control of Pollution) Act 1981 to arrest the deterioration in the air quality. The act prescribes various functions for the Central Pollution Control Board (CPCB) at the control level and State Pollution Control Boards at the state level. The main functions of the Central Pollution Control Board are as follows:

- To advise the Central Government on any matter concerning the improvement of the quality of the air and the prevention, control and abatement of air pollution.
- To plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution.
- To provide technical assistance and guidance to the State Pollution Control Board.
- To carry out and sponsor investigations and research related to prevention, control and abatement of air pollution.
- To collect, compile and publish technical and statistical data related to air pollution; and
- To lay down standards for the quality of air.

The main functions of the State Pollution Control Boards are as follows:

- To plan a comprehensive programme for prevention, control and abatement of air pollution and to secure the execution thereof.
- To advise the State Government on any matter concerning prevention, control and abatement of air pollution.
- To collect and disseminate information related to air pollution.
- To collaborate with Central Pollution Control Board in programme related to prevention, control and abatement of air pollution; and
- To inspect air pollution control areas, assess quality of air and to take steps for prevention, control and abatement of air pollution in such areas.

National Ambient Air Quality Standards (NAAQS)

The ambient air quality objectives/standards are pre-requisite for developing program for effective management of ambient air quality and to reduce the damaging effects of air pollution. The objectives of air quality standards are:

- To indicate the levels of air quality necessary with an adequate margin of safety to protect the public health, vegetation and property;
- To assist in establishing priorities for abatement and control of pollutant level;
- To provide uniform yardstick for assessing air quality at national level; and
- To indicate the need and extent of monitoring programme.

The Central Pollution Control Board had adopted first ambient air quality standards on November 11, 1982 as per section 16 (2) (h) of the Air (Prevention and Control of Pollution) Act, 1981. The air quality standards have been revised by the Central Pollution Control Board on April 11, 1994 and were notified in Gazette of India, Extraordinary Part-II Section 3, sub section (ii), dated May 20, 1994. The revised National Ambient Air Quality Standards are depicted in Annexure-I (Table A-1.1). The guidelines for declaring sensitive areas as recommended by peer/core group of CPCB are as follows:

Sensitive areas - sensitive area may include the following:

i. 10 kms all around the periphery of health resorts that are notified by State Pollution Control Boards in consultation with department of public health of the concerned state.
ii. 10 kms all around the periphery of biosphere reserves, sanctuaries and national parks that are notified by Ministry of Environment and Forest or concerned states.
iii. 5 kms all around the periphery of an archeological monument declared to be of national importance or otherwise that are notified by Archeological Survey of India (A.S.I.) in consultation with State Pollution Control Boards.
iv. Areas which are delicate or sensitive to air pollution in terms of important agricultural/horticultural crops grown in that area and accordingly notified by State Pollution Control Boards in consultation with department of agriculture/horticulture of concerned state.
v. 5 kms around the periphery of centers of tourism and/or pilgrim due to their religious, historical, scenic or other attractions, that are notified by department of tourism of the concerned state in consultation with State Pollution Control Boards.

National Air Quality Monitoring Programme (N.A.M.P.)

Present status of NAMP:

Central Pollution Control Board initiated National Ambient Air Quality Monitoring (NAAQM) programme in the year 1984 with 7 stations at Agra and Anpara. Subsequently the programme was renamed as National Air Quality Monitoring Programme (N.A.M.P.). NAAQS have been notified for seven parameters viz. SPM, RSPM, NO2, SO2, CO, NH3 and Pb. Under National Air Quality Monitoring Programme (NAMP) presently ambient air quality is being monitored at 342 monitoring stations covering 128 cities/towns as on 31st March 2009 which was at 328 stations as on 31st March 2008. During 2008-09, 42 stations have been sanctioned additionally. Further,

i) Parameters SPM, RSPM, SO2 and NO2 are being monitored at all the locations;

ii) Three more parameters i.e. CO, Pb, and NH3 are being monitored at selected locations in a few cities;

iii) Other parameters i.e. O3, Benzene, Trace heavy metals and PAHs are being monitored occasionally at selected locations for creating data base. During the year 2008-09, forty one new air quality stations were sanctioned in cities like Nalgonda,. Kakinada, Warangal, Nellore, Khamam Chitoor, Guntur, Vishakhapatnam, Tinsukhia, Lakhimpur, Nagaon, Nalbari, Bhirwari, Sangli, Roha, Rai Bareli, Gorakhpur, Kanpur, Bareily, Muradabad, Saharanpur, Unnao and Mathura covering three states.

The **objectives of the N.A.M.P.** are as follows:

- To determine status and trends of ambient air quality;
- To ascertain whether the prescribed ambient air quality standards are violated,
- To Identify Non-attainment Cities.
- To obtain the knowledge and understanding necessary for developing preventive and corrective measures;
- To understand the natural cleansing process undergoing in the environment through pollution dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated

Vehicular Pollution Control Measures

I. Vehicular Emission Norms

In order to control vehicular pollution, a road map has been adopted as per the schedule proposed in the Auto Fuel Policy (2002), which includes use of cleaner fuels, automobile technologies and enforcement measures for in-use vehicles through improved Pollution Under Control (PUC) certification system. The vehicle emission norms in India are detailed below.

a) During 1990-91, for the first time in India, notified mass emission norms for vehicles at the manufacturing stage as well as for in-use vehicles were implemented. These norms were notified under the EPA, the Motor Vehicle Rules and the Air Act.

b) The emission norms introduced in 1996 have been crucial in controlling vehicular pollution. For the first time, crankcase and evaporative emission norms were introduced.

c) From April 1995, in the four metros - Delhi, Mumbai, Kolkata and Chennai, passenger cars were allowed to register themselves only if they were fitted with a catalytic converter. Emission norms for such vehicles were stricter by 50 per cent compared to the1996 norms.

d) The testing method for passenger car norms was changed from hot start to cold start. This was a more stringent requirement compared to the earlier one.

e) Year 2000 experienced stricter norms which were already notified in 1997 under the Motor Vehicle Rules. Automobile manufacturers had to undergo major modifications to meet these standards.

f) As per the Hon'ble Supreme Court's directions, only private vehicles conforming to at least EURO-I norms are to be registered. Consequently, in Mumbai, EURO- II norms for private vehicles (4 wheelers) was made applicable from 2001. In Kolkata, India-2000 norms (EURO-I) were implemented from November 1999.

g) From October 1, 1999 emission norms for agricultural tractors were introduced throughout the country. Bharat Stage-II and Bharat Stage-III emission norms for tractors were scheduled to be implemented from 2003 and 2005 respectively.

h) The Bharat Stage-II norms for new 4-wheeler, private non-commercial vehicles were introduced in Mumbai from January 2001 and in Kolkata and Chennai from July 2001 to October 24, 2001.

i) Only those taxies were registered in Delhi, which conformed to Bharat Stage-II norms.

j) Bharat State-II norms for Diesel 4-wheeler transport vehicles were introduced in NCT from 24th October, 2001, and in Greater Mumbai, Kolkata and Chennai from October 31, 2001.

k) An expert committee on the Auto Oil Policy was constituted during September 2001. The interim report of the committee was submitted to the government on January 1, 2000, recommending Bharat Stage-III emission norms for all categories of 4-wheelers in seven mega cities from 2005 and for the rest of the country by 2010. The final report of the committee was submitted in September 2002 and includes the road map for control of vehicular pollution till 2010.

II. Fuel Quality Specifications

For the first time, diesel and gasoline fuel quality with respect to environment related parameters was notified under the EPA in April 1996.

III.Traffic Management

a) Restrictions have been imposed on goods vehicles during day time from August 1999 in Delhi.

b) Left lane of the roads have been made exclusive for buses and other HMV(Heavy Motor Vehicles) in Delhi.

c) Time clocks have been installed at important traffic signals to enable the drivers to switch off their vehicles depending on the time left in the clocks.

d) More fly-overs and subways have been constructed and T-Junctions have been closed for better traffic flow.

IV. Public Transport Systems

a) Number of buses have been increased in major cities to encourage the use of public transportation and reduce private vehicle use.

b) Delhi and Kolkata have introduced the Metro Rail system. The Government of Maharashtra has also developed a master plan for the Mumbai Metro with implementation in three phases over nine corridors. Other states like Karnataka is in the initial phase of implementing Mass Rapid Transit System (MRTS).

c) To provide better public transport and to ease congestion, proposals for Bus Rapid Transit System (BRTS) have been approved for Ahmedabad, Bhopal, Indore, Jaipur, Pune, Rajkot, Vijayawada and Visakhapatnam under JNNURM, covering a total length of more than 310 kms.

V. Reduction of Emissions by Using Lubricants

a) Specifications of 2T oil for two stroke engine with respect to smoke emissions were notified under the EPA in September 1998, for implementation from April 1, 1999 throughout the country.

b) Pre-mix 2T oil dispenser has been installed at all petrol filling stations in Delhi so that excessive oil is not being used by the vehicle owners. Sale of loose 2T oil was banned from December 1998 in Delhi and Kolkata.

VI. Technology

a) Fitting catalytic converter for new petrol passenger cars was made compulsory from April 1, 1995 in four metros and 45 cities from September 1, 1998.

b) Two wheeler scooters with four stroke engine were introduced in the market from October 1998.

c) Registration of only rear engine auto rickshaws was allowed from May 1996 onwards.

VII. Alternate Fuels

a) CNG vehicles were introduced in Mumbai and Delhi. At present more than 80,000 CNG vehicles (19000 cars, 49810 autos, 4935 RTVs & 8874 buses) are plying in Delhi and about 23,000 in Mumbai. All city buses were converted to the CNG mode in Delhi.

b) There are more than 111 CNG filling stations installed in Delhi with an average consumption of 674 tonnes per day of CNG.

c) Emission norms for CNG & LPG driven vehicles have been notified.

d) Petrol vehicles are running on ethanol blended (5 per cent) petrol in states of Maharashtra, Andhra Pradesh, Goa,Gujarat, Haryana, Karnataka, Tamil Nadu, Uttar Pradesh, Daman & Diu and Union Territories of Dadar & Nagar Haveli, Chandigarh and Pondicherry.

e) Planning Commission, Government of India, has announced a National Mission on bio-diesel. Specifications for this have been drafted by the Bureau of Indian Standards (BIS).

VIII. Control of Pollution from In-use Vehicles

Idling emission norms have been notified for in-use vehicles. Pollution Under Control (PUC) certificates are issued for adherence to idling emission norms every 3-6 months. The number of computerized PUC centres in Delhi alone is around 353.

IX. Mass Awareness Programmes

a) Messages/articles related to vehicular emissions are disseminated through newsletters, pamphlets, newspapers, magazines, television, radio, internet, workshops and summer exhibitions.

b) Display of ambient air quality data through display systems in major cities through newspapers, daily news and internet.

c) NGOs working on vehicular pollution control are being encouraged for mass awareness campaigns.

Industrial Pollution Control

The measures taken for controlling air pollution from industries are as follows:

a) Emission standards have been notified under the Environment (Protection) Act, 1986 to check pollution.

b) Industries have been directed to install the necessary pollution control equipments in a time bound manner and legal action has been initiated against the defaulting units.

c) 24 critically polluted areas have been identified. In all, Action Plan has been formulated for restoration of environmental quality in these areas.

d) Environmental guidelines have evolved for siting of industries.

e) Environmental clearance is made compulsory for 29 categories of development projects involving public hearing/NGO participation as an important component of the EIAprocess.

f) Environmental audit in the form of environmental statement has been made mandatory for all polluting industries.

g) Preparation of Zoning Atlas for setting up industries based on environmental considerations, in various districts of the country, has been taken up.

h) Power plants (coal based) located beyond 1000 kms from the pit-head are required to use low ash content coal (not exceeding 34 per cent) with effect from June 1, 2002. Power plants located in the sensitive areas are also required to use low ash coal, irrespective of their distance from the pithead.

CHAPTER V
CONCLUSION

Finally, chapter V covers the conclusion of the study and major findings. This chapter explains the limitations of the study. The chapter also explains the significance of the study and identifies the future areas of research.

The present study has been undertaken with the objective to find out whether relationship between Net State Domestic Production and environment degradation is "inverted U" shaped or not , to find out the relation between Oxides of Nitrogen (NOx) emission and NSDP, to find out the relationship between have Sulphur dioxide (SO2) and NSDP, to find out the relationship between Respirable Suspended Particulate Matter (RSPM) and NSDP and to find out the relationship between Suspended Particulate Matter (SPM) and NSDP.

For achieving the above objectives the following hypotheses have been proposed.

H_1: *The environmental Kuznets curve is applicable for Oxides of Nitrogen (NO_x) emissions*.

From the above graphs and data of NO_2 ,it can be concluded that 3 states **(**Uttar Pradesh, Chandigarh, West Bengal) are not fulfilling the environmental Kuznets curve condition, Chandigarh And Uttar Pradesh are showing U-shape curves whereas, West Bengal is showing N-shaped curve. All other states viz. Andhra Pradesh Gujarat Haryana Karnataka Maharashtra Rajasthan Uttar Pradesh Kerala West Bengal Tamil Nadu Bihar Chhattisgarh Tamil Nadu Bihar Chhattisgarh Jharkhand Assam Madhya Pradesh Orissa Punjab Delhi Himachal Pradesh, Nagaland, Goa are on the marks of Environmental Kuznets curve. The 2 states Meghalaya and Mizoram are *Below Detection Limit (Concentration less than 4 μg/m3*) (BDL). Many of the developing states are on the stage 2 whereas, the less developed states are showing very low concentration of NO_2 emission.

H_2: *The environmental Kuznets curve is applicable for Sulphur dioxide (SO_2) emission.*

The above figures show that 3 states (Tamil Nadu, Madhya Pradesh and Gujrat) are showing inverted N-shape cuve and 3 states (Maharashtra, West Bengal, Haryana) are showing N-shape curve. One state (Delhi) showing U-shape curve and 2 states (Pondicherry, Chhattisgarh) are showing no conclusion. The diagrams are concluding that some of the developed states are showing that sulphur dioxide starts increasing after reaching the 3^{rd} stage. Hence, it can be concluded that environmental Kuznets curve is N- shape in case of sulphur dioxide. The states like Goa, Chandigarh, Nagaland, Mizoram, Meghalaya are *Below Detection Limit (Concentration less than 4 μg/m3*) (BDL). Hence the above hypothesis is partially accepted.

H_3:. *The environmental Kuznets curve is applicable for Respirable Suspended Particulate Matter (RSPM).*

From the above graphs and data of RSPM, it can be concluded that 12 states **(**Andhra Pradesh Gujarat Haryana Karnataka Maharashtra Rajasthan Uttar Pradesh, Tamil Nadu Jharkhand Assam Punjab Delhi Nagaland Goa) are not fulfilling the environmental Kuznets curve condition. Andhra Pradesh, Haryana, Karnataka, Maharashtra, Rajasthan, Punjab, Delhi, Nagaland and Uttar Pradesh are showing N-shape curves and Gujarat is showing inverted N-shaped curve whereas, Tamil Nadu, Jharkhand, Assam and Goa are showing U-shaped curve. Hence the above hypothesis is rejected. As the states become developed they generally follow the Kuznets curve, but with further increase in income they switch to N-shaped curve.

H_4: *The environmental Kuznets curve is applicable for Suspended Particulate Matter (SPM).*

From the above graphs and data of SPM, it can be concluded that 6 states **(**Andhra Pradesh Haryana Karnataka Rajasthan Uttar Pradesh, Tamil Nadu) are not fulfilling the environmental Kuznets curve condition. Andhra Pradesh, Karnataka are showing N-shaped curves and Tamil Nadu is showing inverted N-shaped curve whereas, Haryana, Uttar Pradesh are showing U-shaped curve. Hence the above hypothesis is partially accepted. As the states become developed they they generally follow the Kuznets curve, but with further increase in income they switch to N-shaped curve

Summary of conclusion:

States	SO_2	NO_2	RSPM	SPM
developed states				
Andhra Pradesh	stage 3	stage 3	stage 4	stage 4
Gujarat	Inverted N-shape	stage 3	inverted N-shape	stage 3
Haryana	stage 4	stage2	stage 4	u-shape
Karnataka	stage 3	stage 3	stage 4	stage 4
Maharashtra	stage 4	stage 2	stage 4	stage 3
Rajasthan	stage 3	stage 2	stage 4	stage 4
West Bengal	stage 4	stage 4	stage 3	stage 3
Uttar Pradesh	stage 3	U-shape	stage 4	u-shape
Kerala	stage 3	stage 3	stage3	stage 3
Tamil Nadu	Inverted N-shape	stage 3	U-shape	inverted N-shape
developing states				
Bihar	stage 3	stage 2	stage 2	stage 2
Chhattisgarh		stage 2	stage 3	stage 3
Jharkhand	stage 3	stage 2	U-shape	stage 3
Assam	stage 2	stage 3	U-shape	stage3
Madhya Pradesh	Inverted N-shape	stage 3	stage 2	stage 3
Orissa	stage 1	stage 2	stage 2	stage 2
Punjab	stage 3	stage 2	stage 4	stage 2
Delhi	u-shape	stage 2	stage 4	stage 2
Himachal Pradesh	stage 3	stage 2	stage 2	stage 3
less developed states				
Goa	BDL	stage 1	U-shape	stage 2
Chandigarh	BDL		BDL	stage2
Meghalaya	BDL	BDL	stage 1	stage 2
Mizoram	BDL	BDL	stage 2	
Nagaland	BDL	stage 1	N-shape	stage 2
Pondicherry	Falling	falling	stage 2	bdl

Significance of the Study:

The present study analyses the implication of Economic growth on environment in Indian states. The analysis will help in analyzing the states which are having high economic growth but low level of environmental pollution. The policies followed by these states can help the other states in adopting these for having lower levels of pollution. The analysis will help in analyzing the states reporting higher level of pollution so that steps can be taken to control the situation. Moreover, the work on this field is found less in India as compare to other countries.

Bibliography

Barua and Hubacek ( ) “Water pollution and Economic Growth: An Environmental Kuznets Curve Analysis at the Watershed and State Level.”

Cole and Neumayer (2004): “Demographic factors on air pollution”, 26 (1), pp. 5-21.

Connor, M (2001), “Embodied Pollution in trade: Estimating the “Environmental Load Displacement” of industrialized countries, July.

Eugenio Eigueroa Androberto Pasten: Vol. 36 - N" I. Junio 2009. Págs. 5-32 “Country-Specific Environmental Kuznets Curves:A Random Coefficient Approach Applied Tohigh-Income Countries”

Feridun, Balouga (2006), “Impact of Trade Liberalization on the Environment in developing countries”.

Harris, J (July 2001), “Macroeconomic Policy and Sustainability G-DAE” working paper no.01-09,

Jain and Chaudhuri: The Icfai University Journal of 8 Environmental Economics, Vol. VII, No. 2, 2009 “The Environmental Kuznets Curve: A Reaffirmation”

Kahn, M.E. (1998) “A household level environmental Kuznets curve” December

M. Mazzanti et al. : Vol. 20, No. 3, 277–301, September 2008 “Environmental Kuznets Curves for Air Pollutant Emissions in Italy: Evidence from Environmental Accounts (NAMEA) Panel Data”

M.A. Janssen, J.C.J.M. van den Bergh (2004) : “Into the black box of environmental Kuznets curves: Optimal growth and material resource use in two trading countries”

Matthieu Llorca and Andre Meunie (February 2009)´: “SO2 emissions and the environmental Kuznets curve: the case of Chinese provinces” Vol. 7, No. 1, , 1–16.

Ministry of Environment and forest, Government of India (2009) State of Environment Report India, pp. 9-71.

S. O. Archibald *et al*. (March 2009): “Transition and Sustainability: Empirical Analysis of Environmental Kuznets Curve for Water Pollution in 25 Countries in Central and Eastern Europe and the Commonwealth of Independent States”.

Sanjeev K. Sobhee (2004) “The environmental Kuznets curve (EKC): a logistic curve?” ,pp. 449–452.

Schwartz and Khan (July 2004), “Do richer people pollute more or less? New evidence on household level vehicle emissions Kuznets curve”.

Suri and Chapman (july1998), “Economic growth, trade and energy: implications for the environmental Kuznets curve” .

www.cpcb.com

www.RBI.com

www.state pollution control board.com