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ENVIRONMENT KUZNETS CURVE AND AIR QUALITY: EVIDENCE FROM KERALA

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Abstract

The relation between pollution and economic upsurge has been a matter of debate over a variety of disciplines in the physical and social sciences and the Environmental Kuznets Curve (EKC) hypothesis dominated this discourse. The hypothesis asserts an inverted-U-shaped relation between per capita income and different pollutants i.e., pressure on the environment rise up to a certain threshold as income increases; thereafter, it declines The current study examined the empirical validity of Kuznets inverted U' hypothesis of air pollutants SO2, NOx, RSPM and per capita GDP in Kerala. The information gathered for the study is from secondary sources for the period of 2009-2017.Quadratic regression was done to test the empirical validity of EKC and there is nonexistence of inverted U' hypothesis in all three of the air pollutants. To derive an air quality management in cities an orderly approach should be put in effect by the board of pollution control. Other than domestic air quality governance, there are initiations that are applicable at the national level and are proven to ensure significant air quality advantages globally.

Key Words: GDP per capita, Air pollution, Environmental Kuznets Curve, Kerala.

1. INTRODUCTION

The environment of the world is transient in a unique way in reciprocation to anthropogenic activities. Greenhouse gases such as carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and ozone as well as other particulates such as suspended particulate matter (SPM) and sulphur di oxide (SO2) are being expelled into the atmosphere together with other emissions. The dimensions and composition of the economy is primarily moulded by the environment. This is consistent from domestic economy to economies around the world. Economic practices, in turn, change the environment through the use of resources and the origination of pollution and debris. The relation between pollution and economic upsurge has been a matter of debate o in the physical and social sciences and the Environmental Kuznets Curve (EKC) hypothesis has prevailed this discourse. The hypothesis asserts an inverted-U-shaped relation between different pollutants and per capita income, i.e., pressure on the environment rise up to a certain threshold as income increases; thereafter, it declines.

"The EKC is named for Kuznets (1955) who hypothesized that income inequality first rises and then falls as economic development" (Stern,2004).The EKC follows the same thought of the relationship between equality and development. The distinction is that it looks at

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the environmental equality. Prior to the EKC hypothesis, it was by and large accepted that rich economies destructed the environment at a quicker pace than poor nations. However with the EKC the relationship between the environment well-being and the economy has been reanalysed. The thought is that as economic improvement growth occurs the environment will deteriorate until a certain point where the nation attains particular average income .At that point income is imparted back into the environment and the environment is regained. The economic importance of natural resources is being progressively recognized the environment related to both the costs caused in protecting the environment and the part of the environment in maintaining productive activity such as farming counting the indirect financial benefit it produces. Environmental administration particularly economic arrangement in connection to the to the environment is additionally influenced by the policy environment at all levels. For a state wealth in natural resources such as Kerala and whose economy is altogether related to its natural wealth,issues of environment are especially a source of source of concern. To understand the growth of the economy, the study used per capita net state domestic product at constant price (2011-12) and current price. "The quick estimate of per capita Net State Domestic Product (NSDP) at factor cost at constant prices (2011-12) is ₹4,69,88,233 lakh in 2017- 18 compared to the provisional estimate of ₹4,38,39,422 lakh in 2016-17, recording a growth rate of 7.18 per cent in 2017- 18. At current prices, the NSDP is estimated at ₹6, 19,23,259 lakh (quick estimate) in 2017-18 compared to the provisional estimate of ₹5,55,95,370 lakh in 2016-17. The growth rate of NSDP at current prices is 11.38 per cent in 2017-18 compared to 9.89 per cent in 2016-17" (Economic review, 2018, Kerala State Planning Board, pp-5-7). The growth in the number of motor vehicles, swift in urbanisation and consumerism have led to the contamination of air. Sixty percentage of air pollution caused by motor vehicles and caused diseases like lung problem, head ache etc. Pollution abatement production process has appeared in some industries. But the advantage is being offset by the growth in industries as well as the increase of numbers of vehicles.

The present the study tried to examine the existence of Kuznets inverted U' hypothesis in Kerala using major pollutants such as SO2, NOx and RSPM in Kerala.

2. Economic Development Consequences heading towards Pollution Abatement

The EKC hypothesis has been discussed since 25 years ago in different ways (Stern 2017). Many controversies have circled round the scale of the study, the type of pollutant selected and the comparative determinism of the decrease in pollution over income. More over the curve fails to represent the pollution haven occurrence that is linked to increasing sections of uneven pollution effects. While the World Bank,Shafik (1994) identified that for various pollutants the relation among pollution and income is formed like an inverted U. The inverted U is rather more similar to a cedilla increasing with income, then dropping as the low-hanging fruit of pollution lessing is plucked only to rise again as the fundamental thermodynamic-physical actuality claims itself (Zencey, 2012).

Though the experimental support has only slightly contributed to the mitigation of disparity and ecological degradation with economic expansion (Stern, 2004). The writing at

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this time implies that the EKC is absolutely not deterministic in regarding development pathway, and over there can be changes in its projectile, depending on the pollutant and changes that are frequent in its inflexion, on the basis of type of development path selected. In order to gain a precise knowledge of the relation between growth parameters and pollution, the changes in pollution loading at different times demands to be observed through longer time period along with better granularity in dimensions. Wagner (2007) exposed that in what way EKC evaluations associated with emissions of greenhouse gas can be dismantled if the researcher takes into consideration how the nonlinear transformation of integrated regressors were calculated along with cross-sectional dependence in the data used (World Bank Group 2012).

Kahn (2006) postulates a significant of explanations by EKC regarding how several types of pollution, for instance noise and air even though it is not explaining other forms of environmental damage such as degradation of land, deforestation and erosion of soil, especially in town ecological systems. Grossman and Krueger (1995) employed the air and water quality database from Global Environmental Monitoring System and performed a test which strengthened the EKC conjecture. He arrived at the conclusion that the bending point of the Kuznets curve for majority of the fourteen major pollutants who analysed happened once a nation's yearly per capita income touched $8000. Moreover, the analysis additionally showed various 'baffling' result for instance, coliform bacteria's relationship to income per capita increases over income and after declines but then goes up back after $10000 per capita.The empirical research of Singh and Bhatt (2017)also supported the existence of EKC for NO_x and CO_2 in India.

In a study by Gurluk (2009) conducted among 15 nations in the Mediterranean basin. An Environmental Kuznets Curve is valid for 15 nations in the basin except for France where a quadratic relation similar to an Environmental Kuznets Curve emerged as soon as biological oxygen demand (BOD) was employed as a pollution parameter. The inflection point was determined to be at per capita income of $22161. The remaining nations have either an inverse-logarithmic rising or a logarithmic rising function among BOD and per capita income. Results point at a flaw of deploying econometric techniques in similar analysis as well as where extremely particular variation can be detected with specific pollutants and to calculate some definitive relation between variables in cases that require more qualitative research methods. Hettige *et al* (2000) analysed the effects of income increase on three enablers of pollution: industrial share in national output, the per cent of polluting sections in industrial output, and 'end-of-pipe' (EOP) pollution poignancy per unit of output in the polluting sectors. It was inferred that Kuznets-type trajectory followed the industrial share in national output but their results suggested the denial of the EKC conjecture for water pollution from industry. The sectoral composition adopts a cleaner technology dividend for developing nations with low income, but exhibits an insignificant trend over the middle-income rank. However, EOP pollution intensity decreases all the time with higher income.

(Hajer1996) analysed the causal path through which economic development leads to preservation of environment is showcased using the EKC with regard to consumer force on government to be active using strict rules after achieving a certain threshold income, which

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can then also result of a 'green economy' or 'environmental modernization' for all stakeholders. However environmental activism is not at all correlated with higher income on its own, except in specific situations where it might have more policy effects in rich nations (Mertig and Dunlap 2001). Furthermore, the notion of higher income nations being more environmentally aware is also disputed, as the impoverished might be more eco- friendly as compared to the rich (Martinez-Alier 2003). Moreover, other crucial factors of the Environmental Kuznets Curve could be the effect of trade by which pollution severity in different sectors is plainly outputted to other areas of the globe. Even though this might be consistent for some sectors alike mining of scare earths which mostly transferred to China in accordance to environmental legislations. The embedded pollution of imports indicates progressive switch to greener imports within the United States (Levinson 2010).

Suri and Chapman (1998) in their relative study of nations at different phases of economic expansion found that the growth has been significantly larger in the industrializing nations rather than industrialized nations while both have increased their energy necessity (as a result for environmental effects) by exporting manufactured goods. Concomitantly, industrialized nations are able to mitigate its energy needs by importing manufactured products. They end that the ascending sloping section of the EKC is generated by the exports of manufactured goods and imports have provided to the decline slope of industrialized countries. Rudra and Chattopadhyay (2018) observed the steady increase of CO2 and PM10 in there comparative analysis of different states in India. The inverted U shaped EKC follow in the states of Kerala and Punjab; some other states take long time to reduce pollution

Regardless of the contentions around its experimental findings (Ekins 1997) and the requirements for a further nuanced strategy to pollution policy, the Environmental Kuznets Curve presents a great framework mechanism for greater unveiling the development - pollution dynamic. The rising and falling slants of the curve are therefore treated as significant rule of thumb to carry out investigation in the income and pollution relation.

On the basis of literature regarding various aspect of EKC it is found necessary to deal with the issues related to environment and economic growth in the frame of Kerala economy.

3. Data and Methods

The data collected in the study is comes off secondary sources. Air pollutant figures on SO2, NOx and RSPM are collected from Water and Air Quality Directory of Pollution Control Board (KSPCB), Kerala, for the year 2009 to 2018. KSPCB is observing ambient air quality at 34 locations in Kerala. The geographical areas fall under the categories of industrial, commercial, and residential and sensitive. To study the relation between pollution and economic growth per capita State Net Domestic Product used as proxy variable. Data on Per Capita NSDP was sourced from the different issues of Economic Review, Dept. of Economics and Statistics, Govt. of Kerala.

Explanation of variables

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Sulphur Dioxide is a colourless reactive gas, which is poisonous for animals, human beings and plants.Vechicular emissions, petroleum industries and thermal power plants are the major sources of this gas.

Nitrogen Oxides-The reaction of nitrogen and oxygen gases in the air at the time of combustion, particularly at high temperatures produces NOx. The amount of nitrogen oxides radiated into the atmosphere as air pollution in the regions of high motor vehicle. Whenever combustion occurs in the presence of nitrogen NOx gases are formed (e.g. in car engines), they are also produced naturally by lightning.

Respirable Suspended Particulate Matter -The prime source of high RSPM levels is vehicles. Small scale industries, engine, biomass incineration, resuspension of traffic dust, boilers and emission from power plants, genets, commercial and domestic use of fuels are also responsible for high levels of RSPM.

Model specification

In order to test the EKC hypothesis in Kerala the study employed the quadratic functional form specification which is stated as:

$$lnSO_{2t} = \beta_0 + \beta_1 lnP\_Nsdp_t + \beta_2 lnP\_Nsdp2_t + u_t$$

$$lnNO_{xt} = \beta_0 + \beta_1 \ln\ P\_Nsdp_t + \beta_2 lnP\_Nsdp2_t + u_t$$

$$lnRSPM_t = \beta_0 + \beta_1 lnP\_Nsdp_t + \beta_2 lnP\_Nsdp2_t + u_t$$

The model uses natural logarithm of the variables. The dependent variable used in the above three equations are the state of mean of annual concentration SO2, NOx and RSPM emissions. Coming to the independent variable 'P_*Nsdp*' is the Per capita state domestic product and the Per capita *NSDP* squared is represented with *P_Nsdp2*. The Environmental Kuznets Curve hypothesis is valid if $\beta_1>0$ and $\beta_2<0$ and both are statistically significant. Hence an inverse U-shaped relation can remain i.e. the relationship between air pollution emissions of SO2/NOx/RSPM and per capita NSDP exist with these observations.

4. Results and Discussions

The existence of EKC hypothesis and the shape of EKC is examined with the quadratic forms of coefficients. The coefficients of per capita NSDP and per capita NSDP square is used to find out the impact of emissions of SO2, NOx and RSMP in Kerala .

Table No 4.1: the parameter estimates of Quadratic Emission model in Kerala

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Estimators	Model 1	Model 2	Model 3
	SO2	NOx	RSMP
Constant (β_0)	62.9922(0.038**)	296.411(0.008***)	−109.068(0.108)
P_NSDP	−10.2428 (0.054*)	−51.2639(0.009***)	20.3811(0.088*)
P_NSDP^2	0.447969(0.053*)	2.25839(0.008***)	−0.892108(0.089*)
EKC	No	No	Yes
R2	0.309796	0.492792	0.246521
F Statistics	1.909280 (0.218)	4.201635 (0.063)	1.713373(0.248)

Source: author's calculation from secondary data

*** Significant at 1% level of significance

** Significant at 5% level of significance

*Significant at 10 % level of significance

The table 4.1 depicts the parameter estimates of Ordinary Lest Squares (OLS) for the state of Kerala using the time series data of per capita NSDP from 2009 to 2008. The parameters per capita NSDP and per capita NSDP square are statistically significant for the three models. The estimated test statics for SO2 indicator implies $\beta_1 < 1$ and $\beta_2 > 1$ which means there is no EKC ; though the parameters are significantly influencing SO2 emission in Kerala. In other words, the per capita NSDP is negatively related with SO2 and positively with per capita NSDP square. The R2 value for the model is 0.31 stating that only 31% of the variation is caused by NSDP per capita. While in case of NOx, the estimated statistics provides no EKC . However, the parameters such as NSDP percapita and Percapita NSDP square significantly influence the NOx emission. Like the relationship shown in SO2, NOx also negatively influenced by NSDP per capita and Positively by Per capita NSDP square. Unlike Model 1 and Model 2, Model 3 exhibits the presence of EKC. In model 3, RSMP is positively influenced by per capita NSDP and negatively by Per capita NSDP square. In this three models, per capita NSDP and its square explain the variations in emission is more for NOx as its R^2 is .49. However, the presence of EKC exists only in model 3 where the parameters significantly influence RSMP.

The main factors responsible for the deterioration of air quality and absence of EKC in the state are vehicles and industries. Also, rising use of fossil fuel in the transportation and industrial areas is detrimentally affecting the quality of air in Kerala. The number of vehicles rose two thousand percent from 119720 in 1975 to 2315372 in 2002. The registered motor vehicles as on March 2016 in Kerala are101.71 lakh. Kerala has been a victim of yearly growth rate of above 10 percept for the last 2 decades. The number of vehicles per 1000 population for Kerala in March 2016 is 305. World Development Indicators reported that number of vehicles per 1000 population in India is 18. The rate growth of vehicle population

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is eight per cent over the last year in Kerala. During power outage in summer the industries and commercial enterprises rely on captive power plants or portable generators. This rise in air pollution is due to the greater dependence on fossil fuels. As per 2001 census, urban population of the state is 25.9% of the Kerala's population. Unchecked growth has led to degradation of air quality due to population explosion and traffic congestion. Deterioration of air quality in urban areas has led to increased use of fossil fuels and personal transport. Facilities for scientific management of waste are not available in required numbers even in major cities. Most of the garbage is burned in the open leading to air pollution.

Conclusion

An evaluation of the relationship between economic growth and environmental quality in depicted the of evidence of inverted U hypothesis in the air pollutant RSPM.The other two air pollutant variables SO2 and NOx does not follow the EKC.There are mutual driving forces having differences in shares, in deteriorating air quality in various State/cities of India. All cities need to implement strategies based on their priorities and implications of source apportionment studies. To derive air quality management in cities the study suggests a stepwise approach is listed below:

- Air quality Monitoring system. (already implemented in Kerala)
- Air pollutant emission inventories should be prepared source-wise.
- Source apportionment studies.
- Future air quality projections by making use of dispersion models.
- Appraisal of efficacy of various approaches for control of pollution.
- Cost benefits analysis for short, medium, and longer time frames.
- Framing of air quality governance plans for short, medium, and longer timeframes

Thus the study favoured implementation of selected strategies and appraisal of impact of strategies through monitoring till air quality standard is achieved. Apart from domestic air quality management plans, interventions that are relevant at the national level and those proven to provide significant air quality benefits globally are given.

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