ENVIRONMENTAL KUZNETS CURVE HYPOTHESIS: A CROSS SECTIONAL STUDY

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Abstract

The relationship between economic growth and environment is eminent. Environment provides inputs and necessary services crucial for economic growth. On the other hand economic activities are often associated with the degradation of the environment. The Environmental Kuznets Curve Hypothesis postulates an inverted 'U' –shaped relationship between economic growth and environmental degradation. Accordingly, the environmental degradation increases parallel to economic growth to a certain level of growth achievement. After reaching the economy at this certain critical level of growth the environmental degradation tends to get reduced and the environmental quality improves.

With the above background this paper tries to enquire the nature of relationship between economic growth and environment and also to verify the inverse 'U' relationship between the two variables. For economic growth, as an indicator of growth we are taking per capita income (ppp, 2015) of 105 countries and then relating the values with pollution index, concentration of $PM_{2.5}$ and PM_{10} pollutants in air of same number of countries of the same time period. The method for analyzing the data is graphical. The analysis finds that a trade-off exists between economic growth and environmental degradation. Pollution tends to decline at higher level of growth. Hence this study proves the existence of Environmental Kuznets Curve.

Key Words: EKC, Economic Growth, Pollution

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1. Introduction

The two dimensional relationship between economy and the environment is momentous. The environment provides row material and services essential for the development of an economy. On the other hand the economy disseminates industrial wastes and other pollutants in the environment. The inherent waste-disposal capacity of the environment being limited cannot decompose the pollutants at the rate at which they are emitted. This leads to the concentration of threatening pollutants like greenhouse gases, reduces the fertility of soil, adulterates the water reserve, threatens the biodiversity and eventually becomes a culprit to the entire human race.

Environmental goods were thought to be abundantly available until the 19th century. Faster achievement of economic growth became the main objective of all countries. This goal was being fueled by environmental resources which eventually reduced both the stock and quality of the environmental components. Increased population, competitive exploitation of resources, laissez-faire policy and globalization -these factors altogether deteriorated the environmental quality. Pollution became a common reality but not much attention was paid for its regulation.

Towards the end of the last century the term sustainable development became a popular as well as influential phrase. Defined by Brunt land Commission (1987) as the development which meets the needs of the present generation without compromising the need of the future generation, the term sustainable development, successfully turned the attention of the policy- maker as well as the public towards conservation of environmental properties.

The world today has been suffering from a good number of environmental problems including the global tragedies like the global warming, ozone layer depletion, loss of biodiversity and

many more. Global warming due to the increased concentration of greenhouse gases has threatened the civilization by raising the sea-level, melting the polar ice stock. The increased temperature has also been responsible for some critical diseases like malaria, ZIKA, Bird flu and other mosquito-borne diseases. Climate change has reduced the agricultural productivity worldwide challenging the food security.

On this background the idea of preserving the environmental quality has been increasingly receiving a comprehensive importance in recent decades. In poor countries environmental quality is considered to be a luxury where a faster development is more important. As the economy grows, people's preference moves toward a cleaner environment. Like other criterion the environmental quality also becomes one of the determinants of the value of a site. Therefore it is highlighted that there exists an interesting association between environmental quality and economic growth which changes at different stages of economic growth.

1.1 Economic Growth

An increase in the market value of an economy is termed as economic growth. Real per capita income and real gross domestic product are widely accepted indicators of economic growth. It implies increased capacity of the economy to produce. Growth of the economy can be considered in both real and nominal sense, the latter of which is adjusted in view of inflation. The growth rate of the economy is measured by the trend in the average level of GDP over a certain period.

There are various factors affecting the economic growth. Among them productivity of the factors of production is ordinarily recognized aspect by the theories dealing with economic growth. Technological advancement has become one of the most important determinants of economic growth after the industrial revolution.

1.2 Environment

Environment comprises of all biotic and abiotic elements present in the earth. The biotic elements include all living things encompassing plants, animals and micro-organisms. On the other hand the abiotic domain of the environment is comprised of non-living things including air, water and soil. Technically the environment is divided in four spheres –the lithosphere comprising rocks, the biosphere comprising the living world, the hydrosphere comprising water

bodies on the earth and lastly the atmosphere comprised of air. For lives to exist a sound interaction among these components in the most crucial need.

Environment provides us with resources critical for the growth of the economy. These resources are categorized in two types –the renewable resources which regenerate themselves in a meaningful time frame and the non-renewable resources which do not get renewed in a meaningful time period relevant to economic calculations. Both renewable and non-renewable resources were sufficiently available in the planet but unjust exploitation of resources has aggressively reduced the resource stock predicting a halt of economic growth in the near future.

1.3 Environment Pollution and Pollutants

Presence of substance which adversely impacts the usefulness of resources is called environmental pollution. It may be of four types –the air pollution, the water pollution, the soil pollution and the noise pollution. Environmental pollution not only interferes the working of the ecosystem but also creates a long run negative impact on economic growth.

There are various types of pollutants depending upon the forms of pollution. For air pollution the pollutants are classified as **PM_{10} and $PM_{2.5}$**. The particulate matter or PM is a mixture of solids and liquid droplets floating in the air. PM_{10} pollutants are those with a diameter of 2.5 to 10 micrometers. Sources of this type of pollutants include crushing or grinding operations and dust stimulated up by vehicles on roads. On the other hand the $PM_{2.5}$ pollutants, also known as fine particles are those with a size not exceeding 2.5 micrometers. These polluting particles get emitted in the atmosphere from motor vehicles, power plants, forest fires and agricultural burnings. These particulate matters are composed of some polluting gases like sulfur dioxide, nitrogen oxides, carbon monoxide, mineral dust, black carbon etc.

1.3 The Environmental Kuznets Curve (EKC)

Presenting the relationship between economic inequality and economic growth Nobel laureate economist Simon Kuznets in 1955 forwarded a famous hypothesis named after his name –the Kuznets Curve Hypothesis. According to the hypothesis there exists an ‘inverted U’ relationship between economic inequality and economic growth; during the initial phase of economic growth,

inequality continues increasing. This process continues until a certain critical level of growth is reached, after which because of certain reasons economic equality tends to improve.

In 1995 economist Grossman and Krueger found that the Kuznets curve hypothesis can be extended to present the relationship between economic growth and environmental degradation. They postulated that there exists an 'inverse U' type of relationship between economic growth and environmental degradation. During the initial phase of economic growth when growth is fueled using environmental resources the environment quality tends to deteriorate which continues to a certain critical level of growth. Further economic growth, beyond this level results a continuous improvement in the environment quality. Therefore there exist an interesting trade-off between economic growth and environmental quality. In other words during initial stage of economic growth there is positive relationship between growth and environmental degradation which starts turning to a negative relation when growth exceeds a certain critical level. This 'U'-shape relationship is revealed by the famous Environmental Kuznets Curve (EKC) shown by the figure-1. We have taken per capita income as the indicator of economic growth.

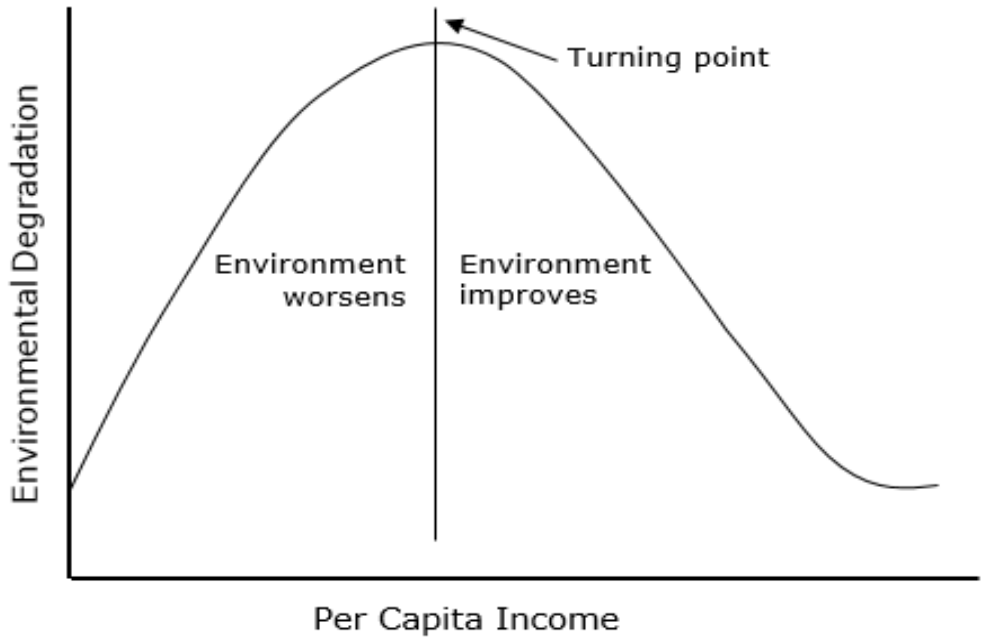


Figure 1

2.0 Review of Literature

Grossman and Krueger (1995) examined the relationship between per capita income and various environmental indicators (including urban air pollution, the state of the oxygen regime in river basins, fecal contamination of river basins, and contamination of river basins by heavy metals) with panel data analysis on pollution levels in some countries. They found no evidence that environmental quality deteriorates steadily with economic growth. Rather, for most indicators, economic growth brings an initial phase of deterioration followed by a subsequent phase of improvement. Their study concluded that while continuance of economic growth is be associated with worsening environmental conditions in very poor countries, air and water quality appear to benefit from economic growth once some critical level of growth is achieved.

Stern and Michael (1996) critically examined the concept of the environmental Kuznets curve (EKC). They also identified some econometric problems with estimates of the EKC, and reviewed a number of empirical studies. They found that whether development will reduce environmental degradation or not is dependent on the assumption that world per capita income is normally distributed.

Vasilev (2000) tested the effect of gross domestic product (GDP) per capita on pollution. For pollution indicator the researcher took carbon dioxide emission. Using Ordinary Least Squares estimation procedure he found a quadratic relationship between CO_2 emissions and GDP per capita in a cross-section of world country data of 2000, thus proving the existence of Environmental Kuznets Curve.

Stern (2003) found that the statistical analysis on which the environmental Kuznets curve is based is not robust and there is little evidence for a common inverted U-shaped pathway which countries follow as their income rises. He suggests that the hypothesis should be tested with more rigorous time series or panel data methods.

Himani (2010) conducted a study on the evidence of the Environmental Kuznets Curve taking data of 2004 -2008 of 24 Indian states. Taking four pollutants namely Suspended Particulate Matter, Respirable Suspended Particulate Matter, Sulphur dioxide and Nitrogen Oxide and then relating the pollutants to state domestic product for factor cost the researcher finds that for Nitrogen Oxide and Suspended Particulate matters an inverted 'U'-shape relationship exists though its exactness varies from state to state.

Lapinskiene and Vaitkus (2013) analyzed the relationship between greenhouse gases (GHG) and gross domestic product (GDP), extending the research to include some additional factors,

such as environmental tax, research and development expenditure, implicit tax rate on energy etc. The researchers first determine the validity of the reduced EKC for the Baltic region for the period 1995-2008. Then the impact of selected factors is statistically tested using the standard cubic equation. The research confirmed the presence of the inverse U-shaped relationship between environmental degradation and economic growth.

Sebri (2015) made use of cross-section data to examine how the per capita water footprint varies as a function of per capita income within the environmental Kuznets curve framework. His estimation results did not reveal any evidence in favour of an inverted-U environmental Kuznets curve, but they yield, in most cases, an evolution into an N- shaped relationship. This suggests that water footprint rises in the beginning with incomes, then falls and as economies grow wealthier it rises again at very high income levels.

2.1 Research Gap

Review of literature reveals that research work on the Environmental Kuznets Curve is insufficient. There are two reasons behind this; firstly the hypothesis is comparatively new in economics as it was formulated only in 1995. Secondly research work to test the validity of this hypothesis requires sufficient time series and panel data but reliable data required for this purpose,especially data on environmental indicators is not available. Use of cross section data of different countries can be made use as substitute of time series data. Research work conducted using cross section data is also very insufficient.

3.0 Objectives of the Study

The objectives of the study are:

1. To check the nature of relationship between environmental degradation and economic growth.
2. To check the existence of inverted ‘U’ –Shape relationship between environmental degradation and economic growth.

3.1 Methodology

Data

For economic growth, as an indicator we are using per capita income (Purchasing Power Parity, in USD at current price of 2015) of 105 countries. The data is collected from World Bank.

For environmental degradation we are using three indicators of 105 countries of 2015. The indicators are Pollution Index, Concentration of $PM_{2.5}$ and PM_{10} pollutants per cubic meter in air. The data have been collected from World Health Organization and Numbeo.

The pollution index is constructed by Numbeo by taking into consideration the aspects: The satisfaction with air quality, quality and accessibility of drinking water, water pollution, satisfaction with garbage disposal, noise pollution, green and parks in the city, and feeling of being comfortable to spend time in the city.

Methods

Graphical technique has been used to enquire the relationship between environmental degradation and economic growth. Data has been put in the scattered plot to see the relationship between-

a) Economic growth and pollution index
b) Economic growth and concentration of $PM_{2.5}$ pollutants
c) Economic growth and concentration of PM_{10} pollutants

Polynomial trend line is fitted on the scatter plot and then it is compared with the hypothesized inverted 'U' –shaped curve.

3.2 Research Questions

1. What is the nature of relationship between economic growth and environmental degradation?

2. Does there exist an inverted 'U' –shape type of relationship between economic growth and environmental degradation?

3. Can a certain critical level of economic growth be found: which becomes the turning point of the 'U' –shaped curve?

4.0 Analysis

Table 1 shows per capita income (Purchasing Power Parity) US$ at current prices of 2015 of 105 countries arranged in ascending order. Pollution index (formulated by W.H.O) and the annual concentration of $PM_{2.5}$ and PM_{10} in gram per cubic meter in air are also shown in the table.

Table 1

Serial No	Country	PCI (USD, 2015)	Pollution Index	$PM_{2.5}$	PM_{10}
1	Liberia	455.9	95.29	9.5	59
2	Guinea	531.3	59.09	-	-
3	Afghanistan	594.3	100.34	77	297
4	Ethiopia	619.2	66.74	-	-
5	Nepal	743.3	83.39	50	114
6	Tanzania	879.0	66.78	23	35
7	Senegal	899.6	110.34	40	179
8	Cambodia	1158.7	80.06	-	-
9	Myanmar	1161.5	87.89	30	69
10	Bangladesh	1211.7	93.59	76	153.5
11	Zambia	1304.9	76.12	-	-
12	Ghana	1369.7	109.27	49	98
13	Kenya	1376.7	62.20	-	-
14	Yemen Republic	1406.3	88.53	-	-
15	Pakistan	1434.7	83.73	100.8	364.8
16	India	1593.3	77.72	46	102.1
17	Moldova	1848.11	57.24	-	-
18	Vietnam	2110.9	84.34	28.3	62
19	Ukraine	2115.0	69.88	-	-
20	Honduras	2528.9	75.20	32	58
21	Nigeria	2671.7	76.29	-	-
22	Philippines	2904.2	74.17	31	67.7
23	Bolivia	3076.8	94.05	32	58.5
24	Indonesia	3346.5	74.41	21	48
25	Armenia	3489.1	73.03	-	-
26	Egypt	3614.7	96.62	74.5	137.5
27	Georgia	3757.1	58.79	-	-
28	Tunisia	3822.4	73.54	-	-
29	Mongolia	3967.8	94.55	-	-
30	Guatemala	3903.5	71.14	-	-
31	Albania	3945.2	76.21	-	-
32	Guyana	4127.4	59.09	-	-
33	Algeria	4154.1	68.73	-	-

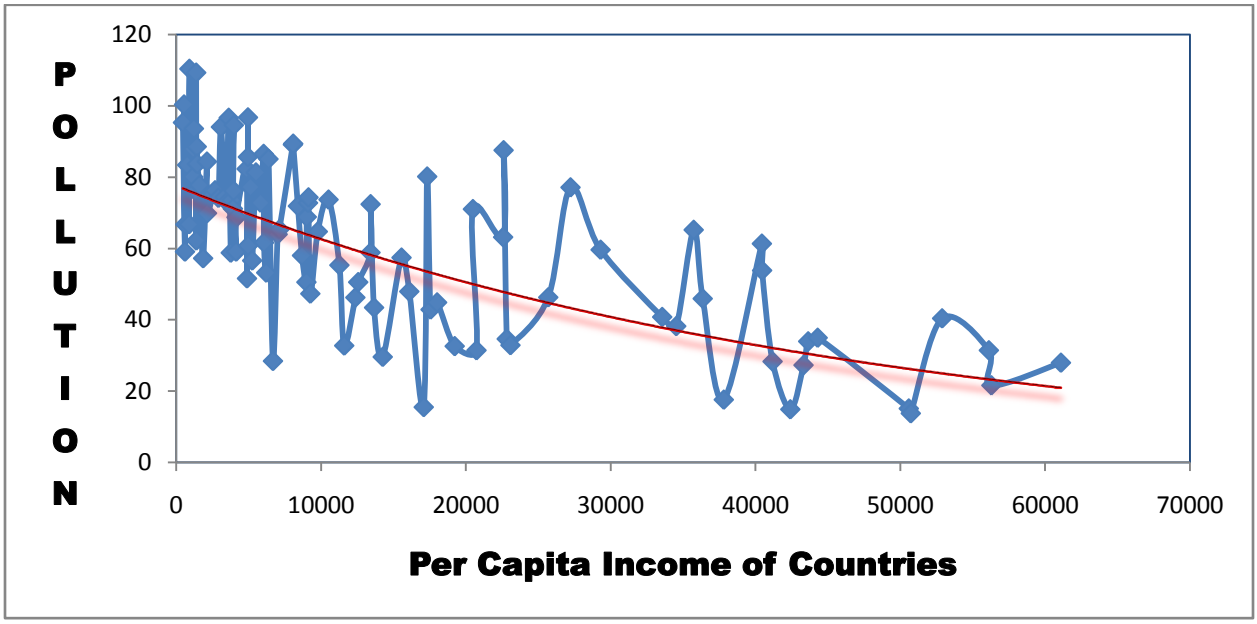
34	Macedonia	4852.7	82.31	-	-
35	Belize	4878.7	51.60	-	-
36	Jordan	4940.0	85.64	48	128
37	Iraq	4943.8	96.72	-	-
38	Fiji	4960.5	60.79	-	-
39	Jamaica	5105.8	77.20	17	31.3
40	Serbia	5237.3	56.60	39.5	59
41	Azerbaijan	5497.5	81.30	-	-
42	Thailand	5814.8	72.81	22.4	41.4
43	Peru	6027.1	86.50	38	63
44	Colombia	6056.1	61.41	23.1	41.2
45	Ecuador	6205.1	53.20	17.4	36.3
46	Botswana	6360.1	85.06	-	-
47	Bulgaria	6993.5	63.96	34.4	51.9
48	Dominica	7116.4	65.32	-	-
49	Lebanon	8047.6	89.11	24.5	72
50	China	8069.2	89.36	40.4	88
51	Maldives	8395.8	71.89	9	20
52	Brazil	8677.8	58.03	19.1	36
53	Romania	8980.7	50.55	19.6	31.8
54	Mexico	9005	68.83	22.2	61.8
55	Russian Federation	9092.6	72.77	22	33
56	Turkey	9125.7	74.31	42.8	63.8
57	Mauritius	9252.1	47.32	26.5	52.5
58	Malaysia	9768.3	64.73	12.4	27
59	Kazakhstan	10510	73.69		
60	Costa Rica	11260.1	55.32	17.8	32.8
61	Croatia	11592.9	32.76	-	-
62	Hungary	12365.6	46.25	25.3	33.3
63	Poland	12558.9	50.55	26.9	37.2
64	Argentina	13407.4	58.86	-	-
65	Chile	13416.2	72.40	24.9	52.8
66	Latvia	13654.8	43.43	16	23
67	Lithuania	14251.8	29.60	14	21
68	Oman	15550.7	57.43	31	82
69	Slovak Republic	16089.0	47.94	26	36.4
70	Estonia	17084.5	15.53	7.3	15
71	Trinidad and Tobago	17321.9	80.15	-	-
72	Czech Republic	17556.9	42.87	23.1	31.5
73	Greece	18607.0	44.87	21.8	28
74	Portugal	19222.9	32.61	11.5	27.3
75	Slovenia	20728.1	31.45	24	31
76	Saudi Arabia	20481.7	71.02	28	87
77	Malta	22567.9	63.17	12	9
78	Bahrain	22600.2	87.52	54.6	249.4

79	The Bahamas	22817.2	34.65	-	-
80	Cyprus	23075.1	32.88	23	36
81	Spain	25684.7	46.30	12.2	22.8
82	Korea Republic	27221.5	77.11	23.4	51.1
83	Kuwait	29300.6	59.63	-	-
84	Brunei Darussalam	33554.7	40.79	-	-
85	Japan	34523.7	38.22	9.2	20.2
86	Israel	35729.4	65.21	30.3	62.5
87	France	36352.5	45.94	17.4	24.2
88	New Zealand	37808.0	17.61	7.6	15.4
89	U.A.E	40438.8	61.34	60	159.7
90	Belgium	40454.2	53.84	17.4	25.8
91	Germany	41178.5	28.32	16.1	21.7
92	Finland	42403.3	14.91	-	-
93	Canada	43315.7	27.30	6.9	20.7
94	Austria	43636.8	33.96	18.8	25.8
95	Iceland	50722.0	13.78	6.3	10
96	Netherlands	44290.9	34.97	16.4	25.4
97	Sweden	50585.3	15.14	9.2	17.3
98	Singapore	52887.7	40.40	17	27
99	United States	56115.7	31.45	9.7	16
100	Australia	56290.6	21.63	6.3	12.7
101	Ireland	61093.7	27.97	8.5	17.5
102	Qatar	73653.4	87.73	89	160
103	Norway	74481.8	23.70	9.5	18.3
104	Switzerland	80999.3	24.07	15.3	22.7
105	Luxembourg	99717.7	33.50	14	18

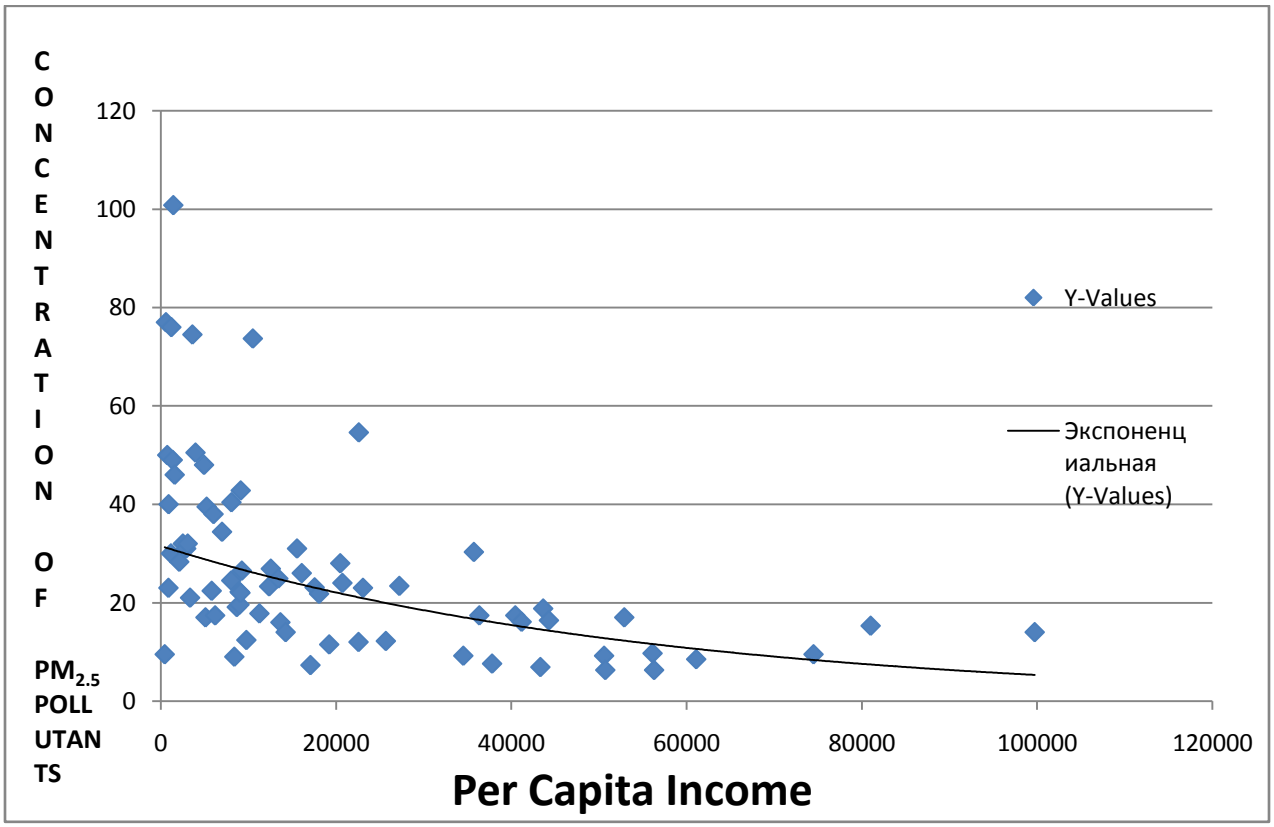
Sources:

a) World Bank
b) World Health Organization
c) Numbeo

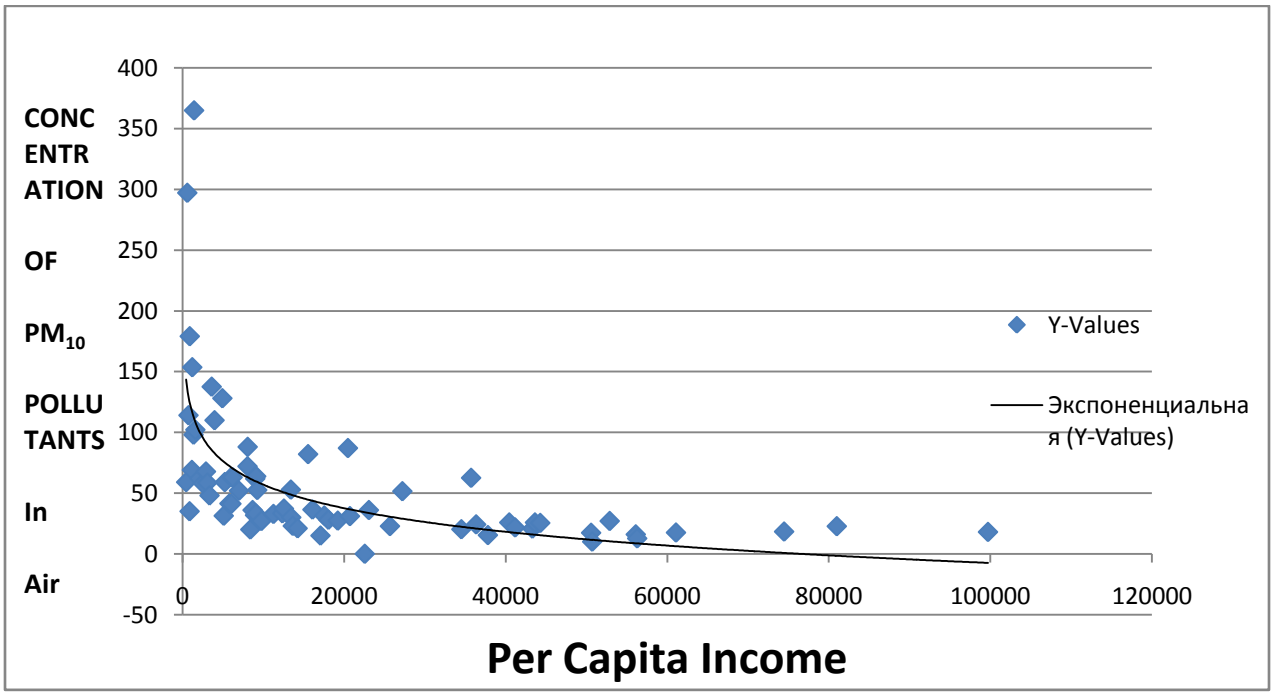
Putting the data in scattered plot the following graphical relationship is found between per capita income (indicator of economic growth) and pollution index.



Employing the same technique the following graphical relationship is found between per capita income and concentration of $PM_{2.5}$ pollutants in air.



Applying the same graphical technique the following relationship is found between per capita income (as indicator of economic growth) and concentration of PM_{10} pollutants in air.



5.0 Findings and Conclusion

The study exposes the following findings:

1. Graphical analysis reveals that trade-off exist between economic growth and environmental degradation which suggests the existence of EKC.
2. Analysis of the cross section data (2015) does not show a perfectly inverted 'U' –shape relationship between economic growth and environmental degradation.
3. Since perfectly 'U' –shaped curve is not found, the critical level of growth, attainment of which influences to improve environmental quality is not found in the study.

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