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Do Developing or Developed Nations Pollute Air More? An Assessment of Health Consequences

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1. Introduction

Air pollution is a serious threat to the healthy life in society. Nations across the continents in the 21st century need to evaluate the air pollution data to make up fair and implementable global policies, which support healthy life. In this process of examining the data, the following relevant question could be answered. Do developing or developed nations contribute more air pollutions? As this chapter illustrates, the pollutions related data in the public domain WebPages (see [1] through [21] for details) hide the answer.

The developing nations aspire to improve their standard of life by advancing their industrial or agricultural productivities. The developed nations, on the contrary, tend to maintain their higher standard of living with the same or more industrial and agricultural productivities. When it comes to a discussion on who contribute the air pollutions, both the developed and developing nations argue and are willing to make a few policy changes but preach and expect the other side to do more to cut down the global air pollutions. How should this escalated conflict be resolved? What do the relevant data suggest? How a compromise between the developed and developing nations is plausible?

To answer this and related questions, this chapter examines and assesses existing global air pollutions data using statistical techniques. The findings as they are stated in this chapter are interesting and pave ways to formulate equitable global policies to reduce air pollutions and thereby increase the healthy life at large.

2. Motivation

Whether air pollutions are natural or human generated, the damages significantly affect the quality of life. Environmentalists warn that the human generated air pollutions are on the rise to an alarming level in the recent years. Such a rise results in tremendous health impacts. The illness and sufferings among the humans, animals, natural life and vegetations are on the steady increase. The land and water sources are also contaminated because of the air pollutions. A recovery from the damages due to the air pollutions requires enormous resources, efforts and money. Many health hazardous chemicals released by the human initiated activities in day-to-day life, in industrial and agricultural sectors are additional add on to the existing natural air pollutions due to phenomena like volcanoes or ozone leaks (see [23] through [28] for details on natural calamities). Some of these hazardous chemicals are absorbed by the air and stay there as permanent air contaminants. Not only the local communities where the air pollutions originate but also those reside in nearby or far away communities suffer as the air contaminants are blown through because of the wind. Consequently, many chronic diseases and illnesses increase everywhere in the world.

The World Health Organization (WHO) estimates over 2.4 million people die each year from the air pollutions. Among those, about 1.5 million deaths are due to the indoor air pollutions. About 310,000 Europeans died in year 2005 alone due to the air pollutions. The number of deaths due to the air pollutions is rising and it is more than the automobile accident deaths. The 1984 Bhopal's Union Carbide disaster caused more than 2,000 deaths and over 500,000 injuries. See [11] and [12] for historical details.

The health effects of the air pollutions include breathing difficulties, wheezing, coughing, pulmonary exacerbations, cancer, respiratory and cardiac failures. Consequently, the consumption of medications and the usage of emergency room visits increase. The hospitals and clinics are overwhelmed by the influx of patients for treatments.

The land and water sources are not immune from the air pollutions. When it rains, because of the air contaminants, the rain exhibits acidity. The acidity in rain causes water pollutions. Especially when the drinking water and arable land receive the acidity, the food chains are contaminated and the public health deteriorates. The land becomes less fertile and the crops are of less safe. The food sources are even depleted in some situations. On the health arena, the acid rain contains a high amount of carbon oxides (CO2), sulfur oxides (SO2) and nitrogen dioxides (NO2). The nations across all continents suffer even though they are not the originators of the air pollutions. The neighboring nations constantly complain to the polluting nations. For an example, Canada, in 1980s, complained to the USA that their air and water pollutions originated in USA and wanted the USA to make remedies. Such complaints were also the reasons for the US congress to legislate the US Clean Air Act of 1990. Similar complaints were lodged by some European nations resulted in the famous Helsinki Protocol Agreement of 1985 in which about 21 European nations committed to reduce their sulfates in the air. Much more, of course, need to be done to alert both the developed and developing nations to commit to drastic improvements for pure air. The findings in this chapter based on relevant data analysis are critical and educational for having healthy life.

Incidentally, drinking the distilled water does not remedy the problem of water contaminations. Why is it so? Though the drinking water contains no carbon dioxide (CO2) after the distillation, its average amount of phosphate (pH) is 5.6μ, which is still acidic. Note that an acceptable pH level in vinegar sold in the supermarkets is only 2.4μ on the average. Thus, the acidity in the rain needs to be taken seriously and corrected. However, the acidity in rain arises from the PM10, sulfuric, carbon or nitrogen oxides in the air.

The acid rain was first noticed in Manchester, England 1852. The carbon, nitrogen, PM10 and sulphate in the air are some important sources of acidity in the rain. The carbon dioxide and the sulfur dioxide (SO2) emanate from the auto emissions. The glacial ice and historical lakes attest to the fact, according to the environmentalists, that the volcanoes and environmental factors such as ozone leaks and deforestation contribute to the increased level of sulfur in the air. The coal and petroleum products contain more sulfur and hence, produce sulfur dioxide upon their combustion. The carbon monoxide and dioxide are due to the combustion of cooking or fossil fuels. The particulate matter (PM10) in the air is quite health hazardous (see [22] and [23] for details). The PM10 are tiny particles of solid or liquid in the gas. The ammonia and chlorofluorocarbons in the air are toxic and are so banned by the environmental protection agency (EPA). The principal and significant causes of the acid

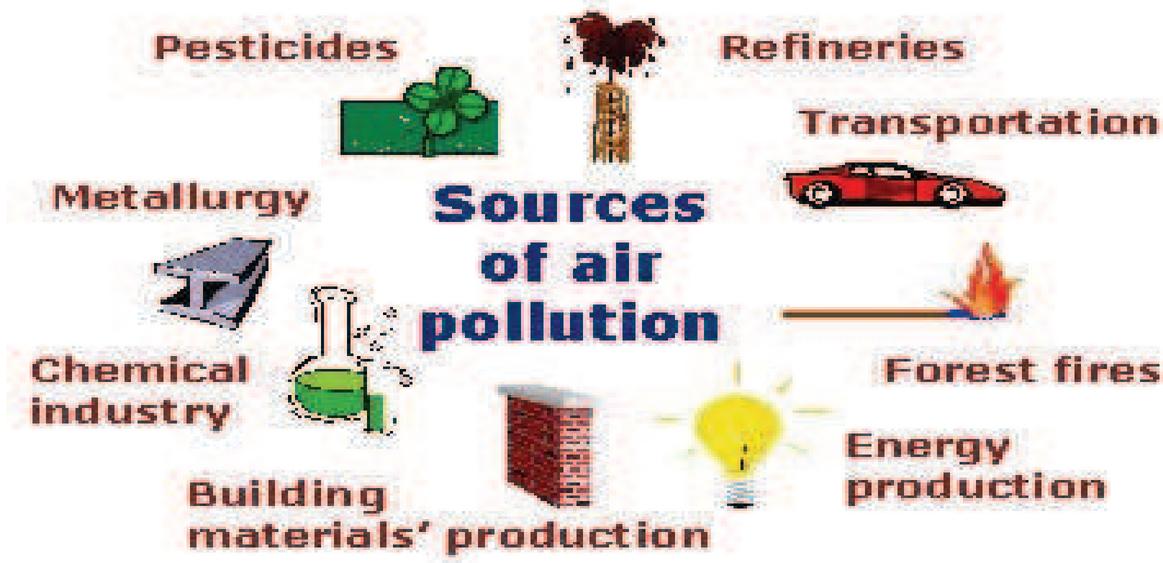

Fig. 1. The group of air pollutants

rain are therefore the chemical compounds emitted by the manufacturing industries or motor vehicles. See Shanmugam et al (2007) for details about the increase in stroke incidences due to the air pollutions. See Figure 1 below for the sources of air pollutions in general.

The developed nations pollute the air by their excessive use of fossil fuels and coal energies in manufacturing industries, oil refineries and the auto emissions in particular. The developing nations aspire to catch up with the developed nations' status and hence add up to the air pollutions by their increased efforts to use excessively the fossil fuels and coal energies in personal and public life. Their use of saltpeter, urea, ammonia (NH_3) and nitric oxides (NO_2) in agricultural activities do contribute to the air pollutions. The farming and agriculture activities in the developing nations are also sources of the air pollutions. Spreading fertilizers and pesticides from the airplanes causes the air pollutions with these solid particles. The soil surface erosions also generate large amounts of particulates with their diameter up to 2.5 μm (the so-called PM 2.5). The particulates are transported in the wind to near and far away communities.

To assess whether the developed and developing nations have parity when it comes to causing the air pollutions, we need to define first who the developed nations are really. How are the developed versus developing nations defined and distinguished? Many definitions are contentious. Could the *per capita income* be an identifier of a developed nation? There might be nations still in developing status though they have a higher per capita income. Could the level of *industrialization* be an indicator of a developed nation? Could the *gross domestic product* (GDP) be an indicator of the developed nations? The list of indicators goes on. The *human development index* (HDI) might be an appropriate and acceptable index according to the discussions in the United Nations, to classify a nation as developed or developing among the members of the United Nations.

If so, what is HDI? The HDI is an aggregate measure of life expectancy, literacy level, education rate, purchasing power and standard of living among the citizens in a nation. The two economists Sen and Haq created the concept and calculating formulas for the HDI during 1990. See [21] for details about the 2010 Human Development Report containing the calculation and interpretation of HDI. In this chapter, the HDI is involved to formulate a list of developed versus developing nations.

2. Do data distinguish developed and developing nations in air pollutions?

To answer this crucial question, an analysis of PM10, sulfuric, carbon or nitrogen oxides emitted to the air by the nations in all continents should be performed. To begin with, for comparisons sake, four groups of nations are formed and considered. All the nations in both the North and South American continental surroundings are grouped together for the analysis. The nations in Asia, New Zealand, Australia and Pacific Oceania are grouped together as part of Asia continental surroundings. The Russia, eastern and western European nations are grouped together as part of European continental surroundings. The Madagascar and all the nations in African continental surroundings are grouped together for the analysis. In all these four groups, there are developed and developing nations. How do these nations perform within the group and across the groups?

The median HDI in each of the four groups of nations is used to classify a nation as a developed or developing in the group. If a nation's HDI is more than the group's median HDI scores, it is a developed nation. See Tables 1 through 4 for the median HDI scores and the status of each nation in the group. Notice that the median HDI scores vary across groups. The median HDI scores are 0.403, 0.695, 0.61 and 0.81 among the 56 African, 51 American, 66 Asian and 54 European nations respectively. Most of the European nations are developed while many of the American nations are developing type. The African and Asian nations are evenly split. The percent of the developed nations are 50, 31, 56 and 61 among African, American, Asian and European continental nations respectively. Hence, no continent contains completely developed nations. A comprehensive, equitable and global air pollution policy is therefore necessary. All members of the United Nations should frame such a policy collectively.

Are the per capita *gross domestic productivities* (GDP) of the developed nations in these four groups close enough? The answer is no as they exhibit a quite heterogeneity according to the Box plots in the Figures 1 through 4 below. The European nations are more homogenous (with the exception of outlier nation Luxemburg). The African nations, American nations (with the exception of outlier nations USA and Canada) and Asian nations (with the exception of outlier nation Qatar) are quite heterogeneous in per capita GDP.

One can not avoid wondering whether the density of the population is a factor in for so much heterogenous per capita GDP or HDI. In fact, it is indeed a factor according to the Figures 5 through 8 which portray the density of the population in millions per square mile. The Asian (with the exception of outlier nations Hong Kong, Taiwan and Singapore) and European (with the exception of outlier nations Belgium, Ireland and Malta) nations have more dense population per square mile than in American (with the exception of outlier nations Bermuda and Barbados) or African nations (with the exception of outlier nations Mauritius, Rwanda and Comoros) in general.

However homogenous or heterogeneous are the nations within the groups, they differ significantly in their contributions to air pollutions. The Figures 9 through 12 portray their contributions to PM10 in the air. The European nations (with the exception of outlier nation Turkey) turn in consistently a low amount of PM10. The Asian nations (with the exception

Countries	HDI	Is it a developed nation?	Countries	HDI	Is it a developed nation?
Algeria	0.677	Yes	Madagascar	0.435	Yes
Angola	0.403	Yes	Malawi	0.385	No
Benin	0.435	Yes	Mali	0.309	No
Botswana	0.633	Yes	Mauritania	0.433	Yes
Burkina Faso	0.305	No	Mauritius	0.701	Yes
Burundi	0.282	No	Morocco	0.567	Yes
Cameroon	0.46	Yes	Mozambique	0.284	No
Cape Verde	0.534	Yes	Namibia	0.606	Yes
Central African Republic	0.315	No	Niger	0.261	No
Chad	0.295	No	Nigeria	0.423	Yes
Comoros	0.428	Yes	Reunion	0	No
Congo (Brazzaville)	0.489	Yes	Rwanda	0.385	No
Congo (Kinshasa)	0.239	No	Saint Helena	0	No
Cote d'Ivoire	0.397	No	Sao Tome	0.488	Yes
Djibouti	0.402	No	Senegal	0.411	Yes
Egypt	0.62	Yes	Seychelles	0	No
Equatorial Guinea	0.538	Yes	Sierra Leone	0.317	No
Eritrea	0.328	No	Somalia	0	No
Ethiopia	0.328	No	South Africa	0.597	Yes
Gabon	0.648	Yes	Sudan	0.379	No
Gambia, The	0.39	No	Swaziland	0.498	Yes
Ghana	0.467	Yes	Tanzania	0.398	No
Guinea	0.34	No	Togo	0.428	Yes
Guinea-Bissau	0.289	No	Tunisia	0.683	Yes
Kenya	0.47	Yes	Uganda	0.422	Yes
Lesotho	0.427	Yes	Western Sahara	0	No
Liberia	0.3	No	Zambia	0.395	No
Libya	0.755	Yes	Zimbabwe	0.14	No
Madagascar	0.435	Yes	Median HDI score	0.403	# developed nations=28

Table 1. Nations in Africa

Countries	**HDI**	**Is it a developed nation?**	**Countries**	**HDI**	**Is it a developed nation?**
Antarctica	0	No	Haiti	0.404	No
Antigua-Barbuda	0	No	Honduras	0.604	No
Argentina	0.775	Yes	Jamaica	0.688	No
Aruba	0	No	Martinique	0	No
Bahamas	0.784	Yes	Mexico	0.75	Yes
Barbados	0.788	Yes	Montserrat	0	No
Belize	0.694	No	Netherlands Antilles	0.29	No
Bermuda	0	No	Nicaragua	0.565	No
Bolivia	0.643	No	Panama	0.755	Yes
Brazil	0.699	Yes	Paraguay	0.64	No
Canada	0.888	Yes	Peru	0.723	Yes
Cayman Islands	0	No	Puerto Rico	0.79	Yes
Chile	0.783	Yes	Saint Kitts	0	No
Colombia	0.689	No	Saint Lucia	0	No
Costa Rica	0.725	Yes	Saint Pierre	0	No
Cuba	0	No	Saint Vincent	0	No
Dominica	0.663	No	Suriname	0.646	No
Dominican Republic	0.663	No	Trinidad-Tobago	0.736	Yes
Ecuador	0.695	Yes	Turks Caicos Islands	0	No
El Salvador	0.659	No	United States	0.902	Yes
Falkland Islands	0	No	Uruguay	0.765	Yes
French Guiana	0	No	Venezuela	0.696	Yes
Grenada	0	No	Virgin Islands, U.S.	0	No
Guadeloupe	0	No	Virgin Islands	0	No
Guatemala	0.56	No	Median HDI score	0.695	
Guyana	0.611	No	# developed nations	16	

Table 2. Nations in South and North America

Countries	HDI	Is it a developed nation?	Countries	HDI	Is it a developed nation?
Armenia	0.695	Yes	Macau	0	No
Afghanistan	0.349	No	Malaysia	0.744	Yes
American Samoa	0.414	No	Maldives	0.602	No
Australia	0.937	Yes	Mongolia	0.622	Yes
Azerbaijan	0.713	Yes	Nauru	0.414	No
Bahrain	0.801	Yes	Nepal	0.428	No
Bangladesh	0.469	No	New Caledonia	0.414	No
Bhutan	0.518	No	New Zealand	0.937	Yes
Brunei	0.805	Yes	Niue	0.414	No
Burma (Myanmar)	0.451	No	Oman	0.49	No
Cambodia	0.494	No	Pakistan	0.49	No
China	0.862	Yes	Papua New Guinea	0.431	No
Cook Islands	0.614	Yes	Philippines	0.638	Yes
Fiji	0.669	Yes	Qatar	0.803	Yes
French Polynesia	0.614	Yes	Samoa	0.49	No
Guam	0.614	Yes	Saudi Arabia	0.752	Yes
Hawaiian Trade Zone	0.902	Yes	Singapore	0.846	Yes
Hong Kong	0.863	Yes	Solomon Islands	0.494	No
India	0.519	No	Sri Lanka	0.658	Yes
Indonesia	0.6	No	Syria	0.589	No
Iran	0.702	Yes	Taiwan	0.869	Yes
Iraq	0	No	Tajikistan	0.58	No
Israel	0.872	Yes	Thailand	0.654	Yes
Japan	0.884	Yes	Timor-Leste	0.502	No
Jordan	0.681	Yes	Tonga	0.677	Yes
Kazakhstan	0.714	Yes	Turkmenistan	0.669	Yes
Kiribati	0.614	Yes	U.S. Pacific Islands	0.614	Yes
Korea, North	0	No	United Arab Emirates	0.815	Yes
Korea, South	0.877	Yes	Uzbekistan	0.617	Yes
Kuwait	0.771	Yes	Vanuatu	0.614	Yes
Kyrgyzstan	0.598	No	Vietnam	0.572	No
Laos	0.497	No	Wake Island	0.614	Yes
Lebanon	0	No	Yemen	0.439	No
#developed nations	37		Median HDI score	0.61	

Table 3. Nations in Asia, Australia, New Zealand and Pacific Islands

Countries	HDI	Is it a developed nation?	Countries	HDI	Is it a developed nation?
Albania	0.719	No	Latvia	0.769	No
Austria	0.851	Yes	Lithuania	0.783	No
Belarus	0.732	No	Luxembourg	0.852	Yes
Belgium	0.867	Yes	Macedonia	0.701	No
Bosnia-Herzegovina	0.71	No	Malta	0.815	Yes
Bulgaria	0.743	No	Moldova	0.623	No
Croatia	0.767	No	Montenegro	0.769	No
Cyprus	0.81	Yes	Netherlands	0.89	Yes
Czech	0.841	Yes	Norway	0.938	Yes
Denmark	0.866	Yes	Poland	0.795	No
Estonia	0.812	Yes	Portugal	0.795	No
Finland	0.871	Yes	Romania	0.767	No
France	0.872	Yes	Russia	0.719	No
Georgia	0.698	No	Serbia	0.735	No
Germany	0.885	Yes	Slovakia	0.818	Yes
Gibraltar	0	No	Slovenia	0.828	Yes
Greece	0.855	Yes	Spain	0.863	Yes
Greenland	0	No	Sweden	0.885	Yes
Hungary	0.805	No	Switzerland	0.874	Yes
Iceland	0.869	Yes	Turkey	0.683	No
Ireland	0.895	Yes	Ukraine	0.71	No
Italy	0.854	Yes	United Kingdom	0.849	Yes
#developed nations	33		Median HDI score	0.81	

Table 4. Nations in Europe

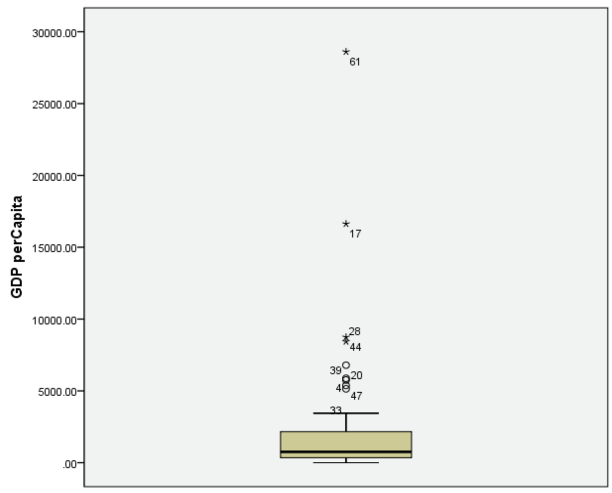

Fig. 1. GDP in Africa

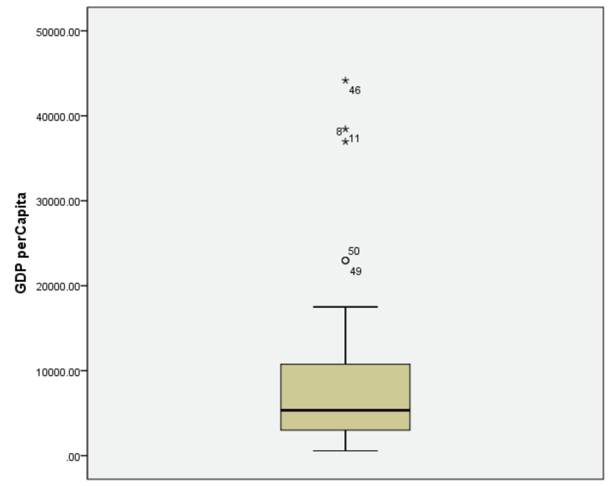

Fig. 2. GDP in America

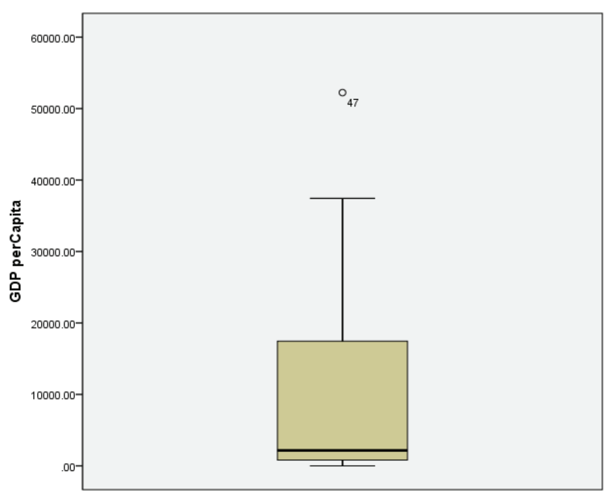

Fig. 3. GDP in Asia

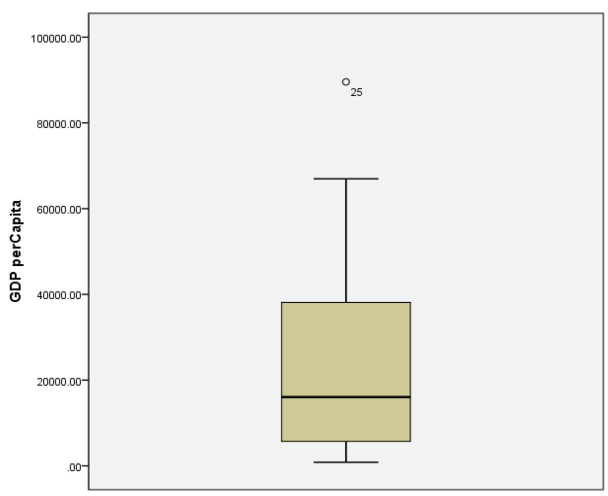

Fig. 4. GDP in Europe

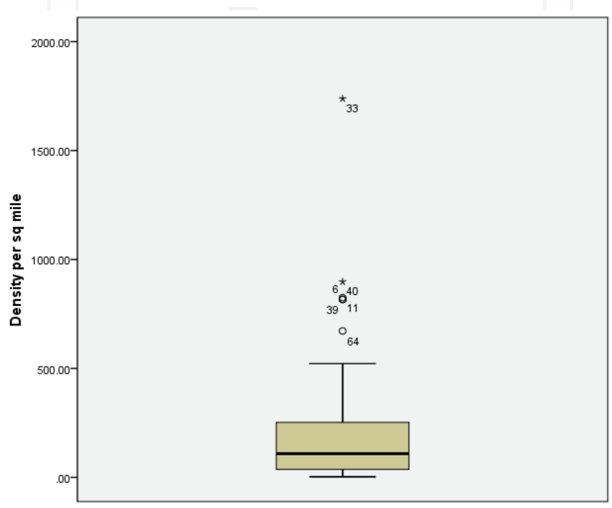

Fig. 5. Density/Square mile in Africa

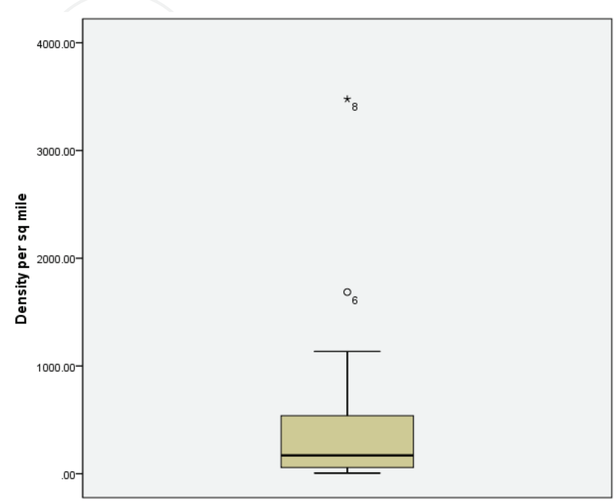

Fig. 6. Density/Square mile in America

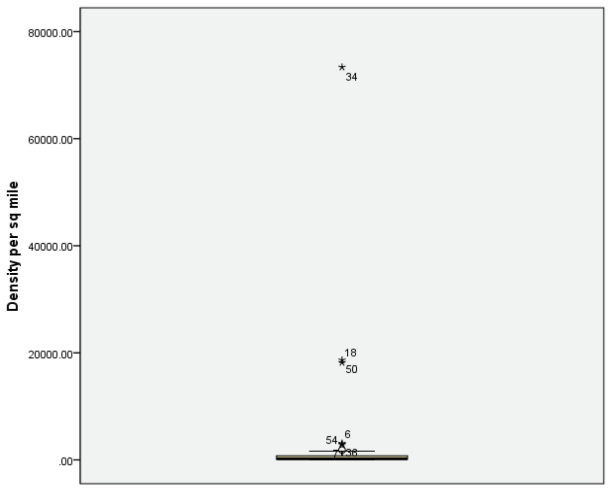

Fig. 7. Density/Square mile in Asia

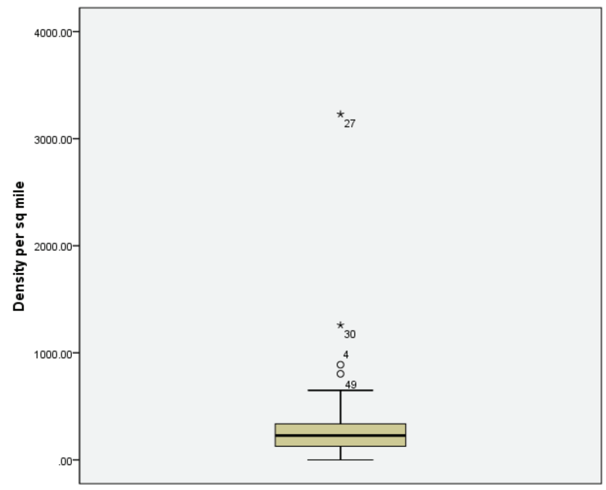

Fig. 8. Density/Square mile in Europe

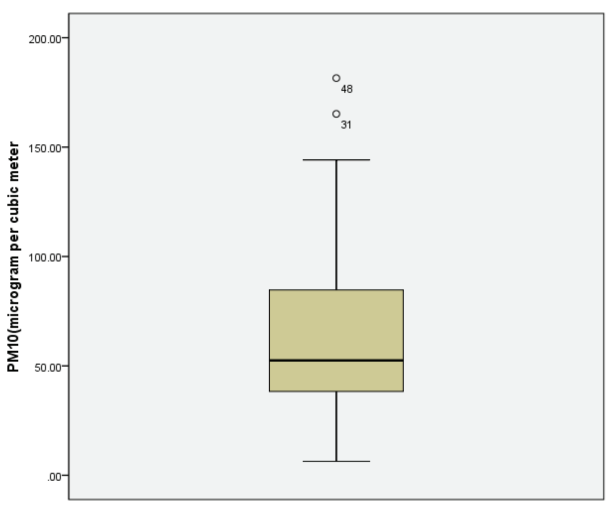

Fig. 9. PM10 in Africa

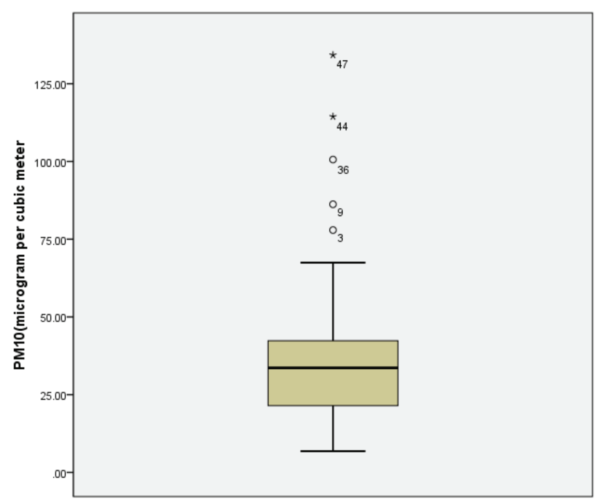

Fig.10. PM10 in America

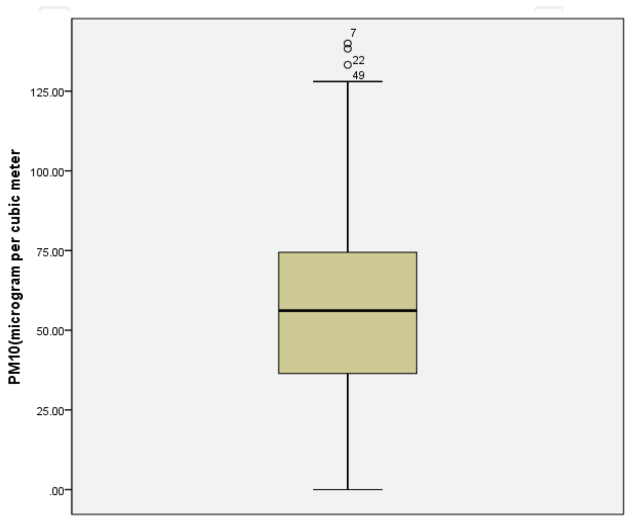

Fig. 11. PM10 in Asia

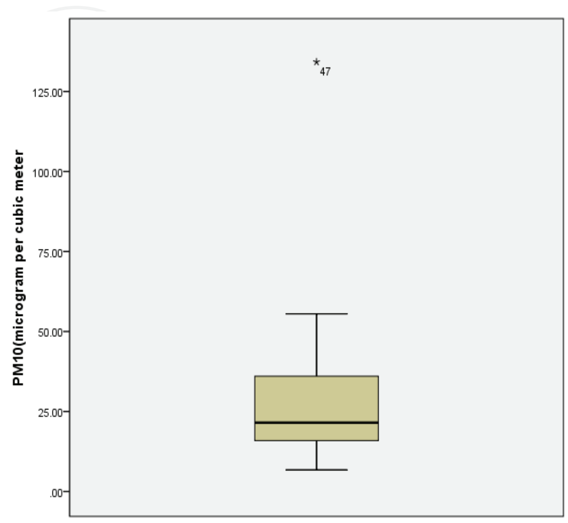

Fig. 12. PM10 in Europe

of outlier nations United Arab, Saudi Arabia, Bangladesh and Iraq) turn in a high amount of PM10. Though the median amount of PM10 is same in both the African and American nations, the nations within each group differ quite a bit. The African nations (with the exception of outlier nations Mali and Sudan) have much different PM10 while there are outlier nations in American continents like Paraguay, Trinidad and Uruguay. It appears that the presence of excessive PM10 in the air is due to industrial and agricultural sectors.

The contributions by the nations to the carbon dioxide (CO_2) in the air also differ significantly. The Figures 13 through 16 exhibit the CO_2 per capita in metric tons. The per capita CO_2 in Asia (with the exception of outlier nations Bahrain, Kuwait, Qatar and United Arab) and in Africa (with the exception of outlier nations Equatorial Guinea, Libya, Seychelles and South Africa) are low. The per capita CO_2 in America (with the exception of outlier nations USA, Aruba, Antilles and Trinidad) and in Europe (with the exception of outlier nations Belgium, France and Luxemburg) are high. It appears that the presence of excessive CO_2 in the air is due to industrial sectors.

The sulfur dioxide (SO_2) in metric tons are illustrated in Figures 17 through 20. The SO_2 is low in Asia (with the exception of outlier nations Tajikistan, Australia, China, South and

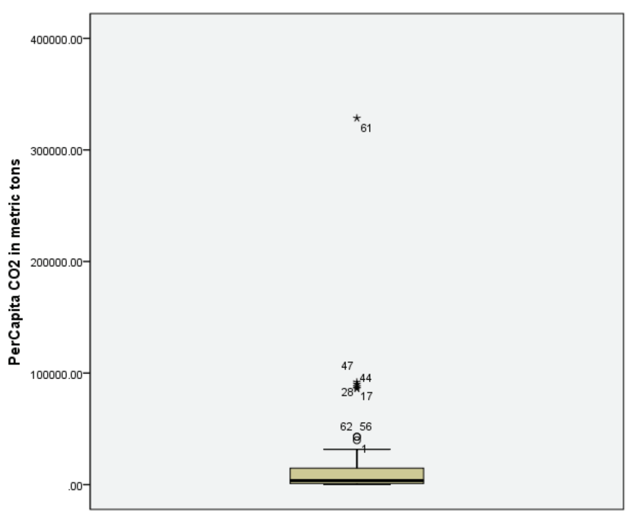

Fig. 13. Per capita CO2 in Africa

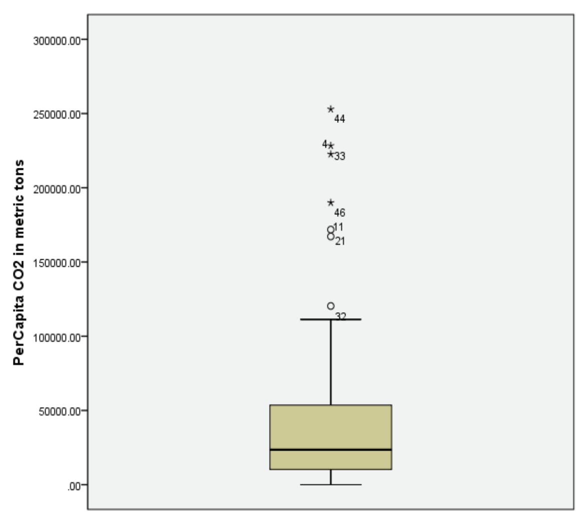

Fig. 14. Per capita CO2 in America

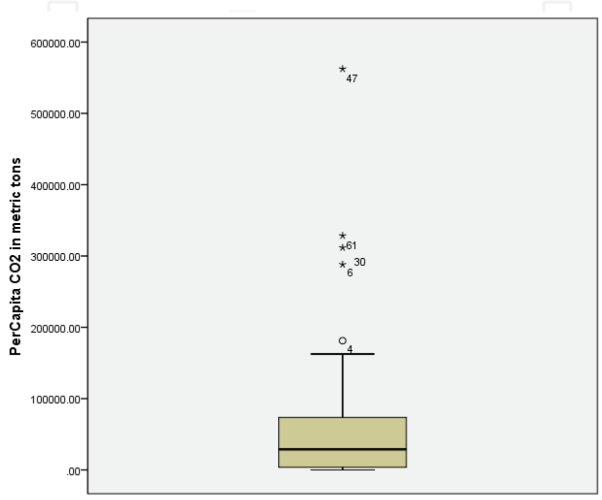

Fig. 15. Per capita CO2 in Asia

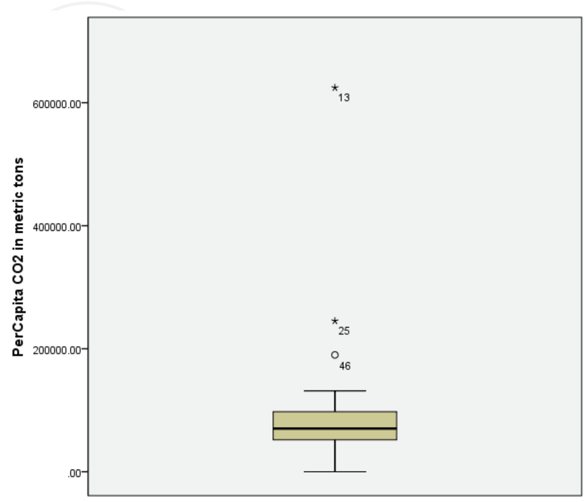

Fig. 16. Per capita CO2 in Europe

North Koreas) and in Americas (with the exception of outlier nations Jamaica, USA and Canada). The SO2 is more in Europe (with the exception of outlier nation Belgium). There are outlier nations in Africa (with the exception of outlier nations Egypt, Libya and South Africa) when it comes to the SO2 level. It appears that the presence of excessive SO2 in the air is due to energy sectors.

The nitric oxide (NO2) level in metric tons are displayed in Figures 21 through 24 for the nations in Africa, America, Asia and Europe. The NO2 is more in Africa (with the exception of the outlier nations like Congo, Ethiopia, Nigeria, Sudan and Tanzania) than in Asia (with the exception of the outlier nations like Cook Island and India). The NO2 in America (with the exception of the outlier nations like USA, Canada and Virgin island) and in Europe (with the exception of the outlier nations like Germany, Russia, Spain and United Kingdom) are low. It appears that the presence of excessive NO2 in the air is due to the agricultural sectors.

3. Clusters of nations based on the principal components

In the previous section, it was noticed that the developing and developed nations contribute differently to the air pollutions. A natural follow up question is then whether the nations within a group pollute more in a single contamination or in all of CO2, NO2, SO2 and PM10. How these contaminations are matching up with the factors such as acidity in the rain, the population density per square mile, the per capita GDP, the percent contribution to the global emission, the per capita expenditure in budget for public health, the incidences of lung cancer and cardiovascular deaths? An answer to this question resides on the significance of their partial correlations after controlling the HDI variable.

For this purpose, let r denote the partial correlation between two factors after controlling the HDI variable. Only among the nations in Africa (but not in American, Asian or European nations), the per capita carbon dioxide (CO2) is significantly correlated with the emission level (that is, $r = 0.8$). In Africa and in Asia, the per capita budget amount spent on the health services is significantly correlated with the per capita CO2 level (that are, $r = 0.9$ and0.9 respectively). Interestingly, only in American nations, the partial correlation between the per capita CO2 and the PM10 is significant (that is, $r = -0.9$). Among the European nations, the per capita CO2 and the nitric oxide (NO2) are significantly correlated (that is, $r = 0.7$).

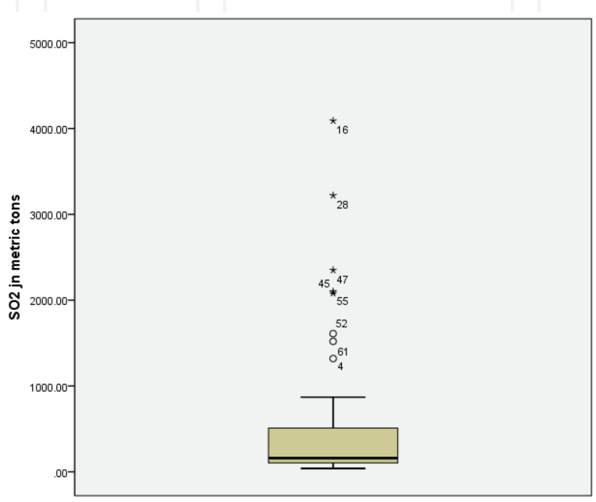

Fig. 17. SO2 in Africa

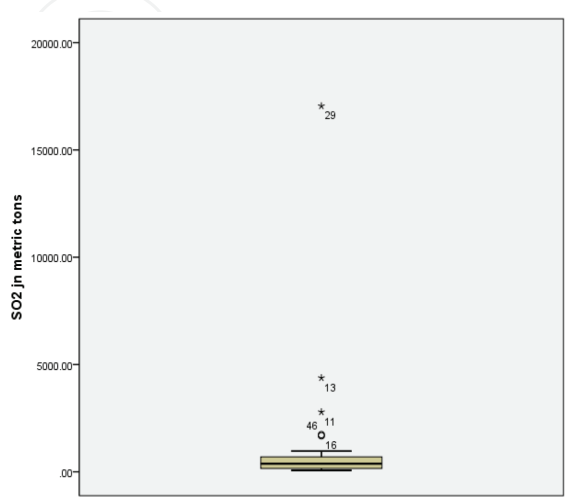

Fig. 18. SO2 in America

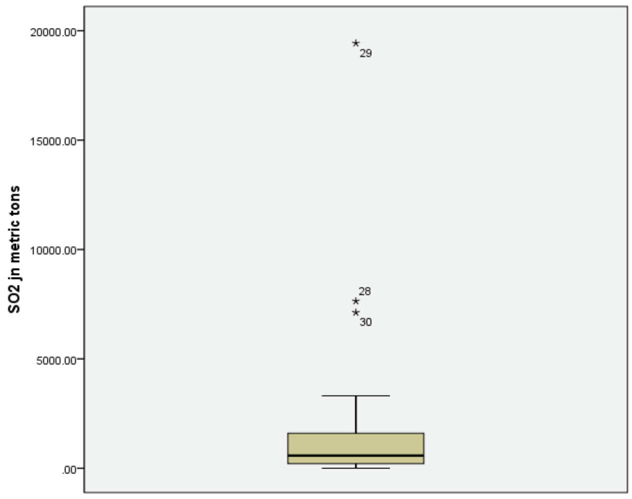

Fig. 19. SO2 in Asia

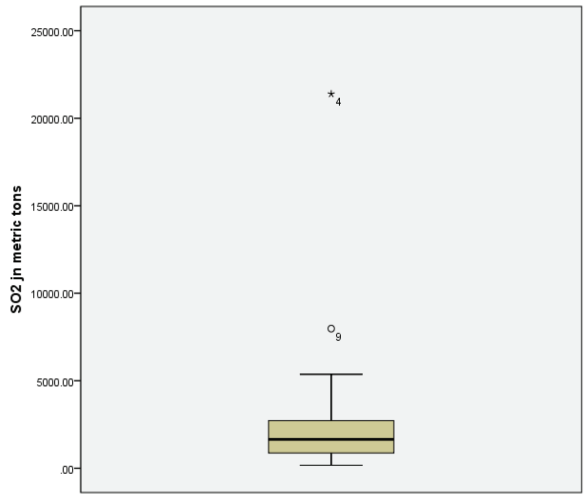

Fig. 20. SO2 in Europe

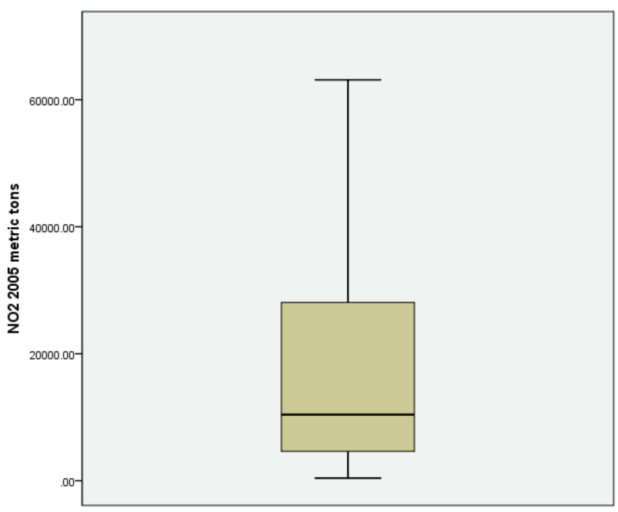

Fig. 21. NO2 in Africa

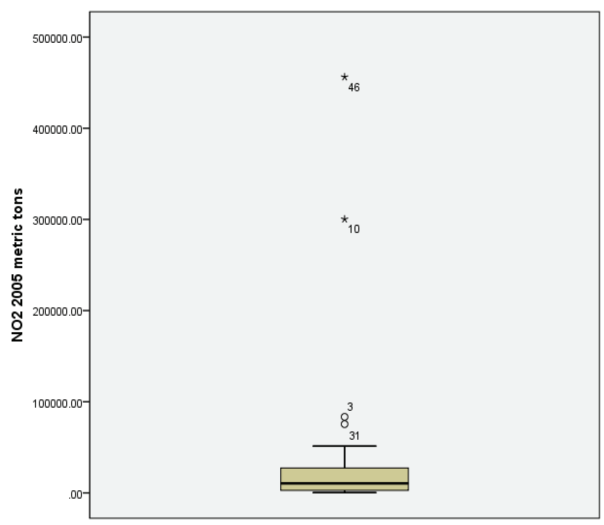

Fig. 22. NO2 in America

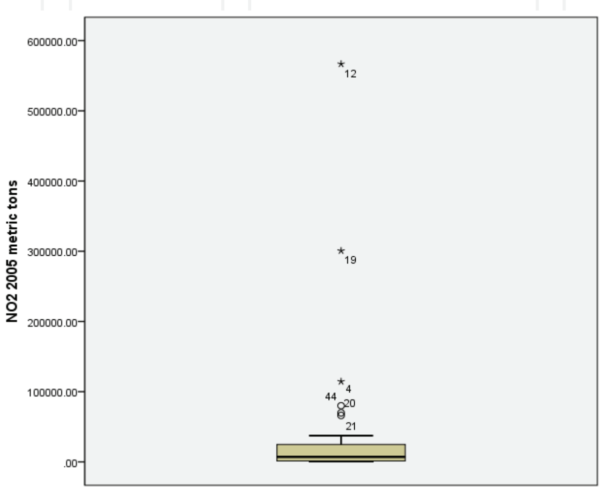

Fig. 23. NO2 in Asia

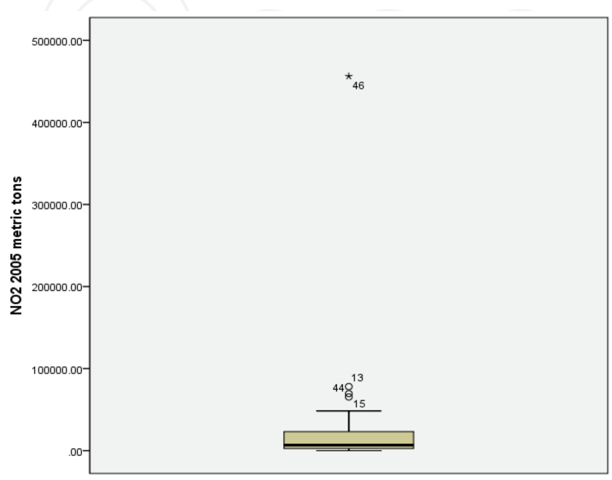

Fig. 24. NO2 in Europe

The acidity in the rain is significantly correlated with the population density per square mile only in African (that is, $r = 0.9$) and in Asian nations (that is, $r = 0.6$). In other words, the acidity in the rain is more where more people live in Africa and in Asia. These types of relations do not exist significantly in Americas or Europe. Only in Americas (that is, $r = 0.9$), the expenditure on health improvement has increased along with the acidity in the rain. The acidity in the rain is significantly more with the higher sulfur dioxide only in Asia (that is, $r = 0.7$) and in Europe (that is, $r = 0.5$).

Strangely enough, higher the PM10 means lower the per capita CO2 only in Americas (that is, $r = - 0.9$). Such a significant relation is not noticed in Africa, Asia or Europe. In Asia (that is, $r = 0.5$) and in Europe (that is, $r = 0.5$), more sulfur dioxide occurs when there is a higher density of population. In Asia (that is, $r = 0.9$) and in Europe (that is, $r = 0.7$), cardiovascular deaths increase significantly with the higher nitric oxide (NO2) level. This pattern does not exist in Africa or Americas. The emission level is significantly higher in higher density of nations only in Asia (that is, $r = 0.9$) but not in America, Africa or Europe.

No clear consistent pattern among the developed and developing nations either within or across the groups is emerging. It is, therefore, worthwhile to perform the principal component analysis with the data on CO2 from the coal burning, HDI, per capita GDP, CO2, NO2, SO2, PM10, acidity in the rain, population density per square mile, per capita GDP, percent contribution to global emission, per capita expenditure in budget for public health, incidences of lung cancer and cardiovascular deaths. The principal component analysis formulates three major principal components and the aggregate percent of explained total variations in the data. The larger coefficient in the Eigen vector of a principal component signifies a degree of importance of the factor. These important factors are compiled and summarized in Table 5 below for each of the four groups. The first principal component 1 (PC1) contains the most important pollution variables and these are followed by the next round of data variables in the principal component 2 (PC2). The final round (because only three principal components were chosen to begin with) of pollution variables are selected in the third principal component (PC3).

Notice that the coal burning is identified in the PC1 itself for all continents. The CO2 in the air is serious in Africa and Asia. The emissions cause major air pollution in all the continents. The GDP is quite diversified in Africa and Americas. Only in Asia, the health expenditure is not causing variation in the data. An implication is that the nations in Asia spend more for health. The nations in Africa, America and Europe spend significantly not enough amounts for the health. The SO2 and NO2 in the air are quite different in Africa and in Asia respectively. The Asian nations are more agricultural and hence the NO2 is major air pollution in there. The oil refineries and petroleum industries cause significant air pollutions in Africa. The lung cancer deaths are significantly large and serious in Americas. The cardiovascular deaths are significant in Asia and Europe.

In the next round of importance, the acidity in the rain is quite serious and it occurs in high population density areas in Africa only. The HDI appears only in the second round of importance and it is more so in Asia only. The cardiovascular deaths are seriously important in the second round in Africa and America. Other important factors in America are NO2. In Asia, the important factors in the second round are HDI, CO2, the per capita GDP and health expenditure. In Europe, the CO2 and NO2 are serious air pollutions.

In the third round, the HDI, PM10 and NO2 are important factors in Africa and only PM10 is important in America. The acidity, high population density areas and SO2 are important factors in Asia and only SO2 is an important factor in Europe so far as air pollutions. See Figures 25 through 28 for specifics.

Group	Principal Component 1	Principal Component 2	Principal Component 3	Explained variation
Africa	1. Coal burning 2. CO2 3. GDP 4. Health expenditure 5. SO2 6. Emission	1. Acidity 2. Population density 3. Cardiovascular death 4. Lung cancer	1. HDI 2. PM10 3. NO2	89%
America	1. Coal burning 2. HDI 3. Acidity 4. CO2 5. GDP 6. Health expenditure 7. Lung cancer 8. Emission	1. NO2 2. Cardiovascular deaths	1. PM10	72%
Asia	1. Coal burning 2. NO2 3. Cardiovascular deaths 4. Emission	1. HDI 2. CO2 3. GDP 4. Health expenditure	1. Acidity 2. Population density 3. SO2	77%
Europe	1. HDI 2. Health expenditure 3. Cardiovascular deaths 4. Emission	1. CO2 2. NO2	1. SO2	88%

Table 5. Principal factors in all four groups

4. Equitable global air pollution policy for better world health

In this section, the pollutions in both the developed versus developing nations are compared not only within each group but also across the groups. In developed African nations (see Figure 29), in developed America nations (see Figure 31), in developed Asian nations (see Table 33) and in developed European nations (see Figure 35), the per capita carbon dioxide, sulfur dioxide, carbon dioxide from the coal burning, nitric oxide, emissions, acidity and PM 10 are significant pollution variables. In developing African nations (see Figure 30), in developing American nations (see Figure 32), in developing Asian nations (see Figure 34) and in developing European nations (see Figure 36), the carbon dioxide from the coal burning, sulfur dioxide, PM 10, nitric oxide, emission and the carbon dioxide are the pollution variables. There is not much of difference between the developed and the developing nations in African and American continents. All nations are polluting the air significantly.

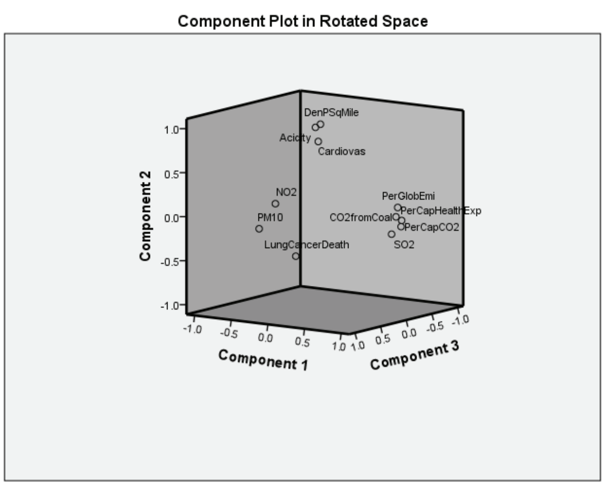

Fig. 25. Significant factors in Africa

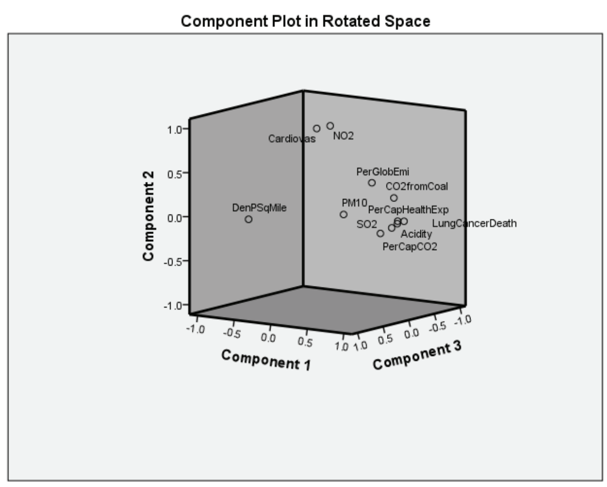

Fig. 26. Significant factors in America

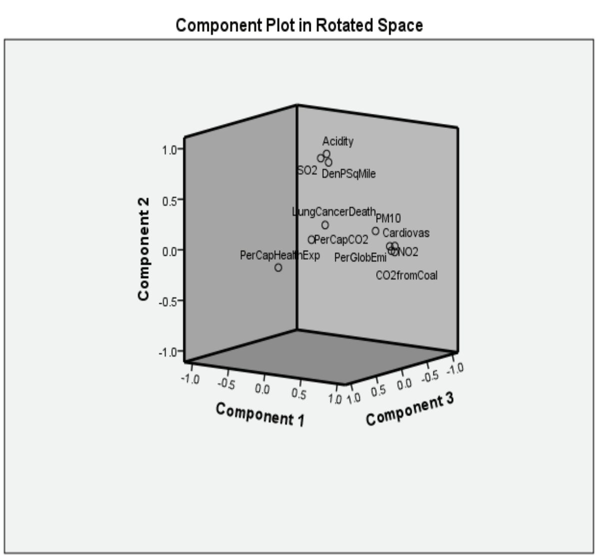

Fig. 27. Significant factors in Asia

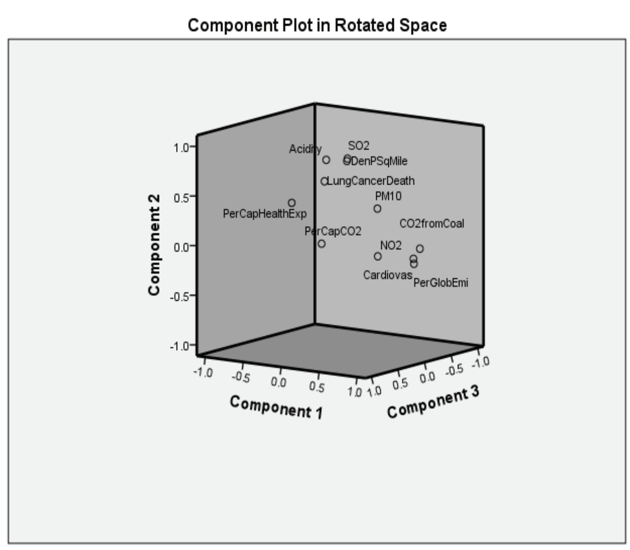

Fig. 28. Significant factors in Europe

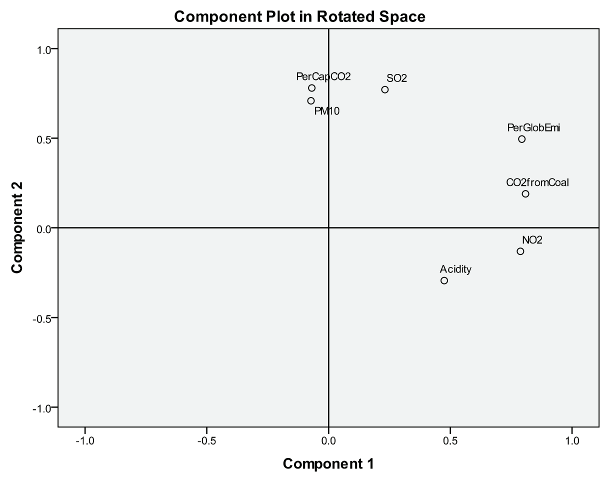

Fig. 29. In developed Africa

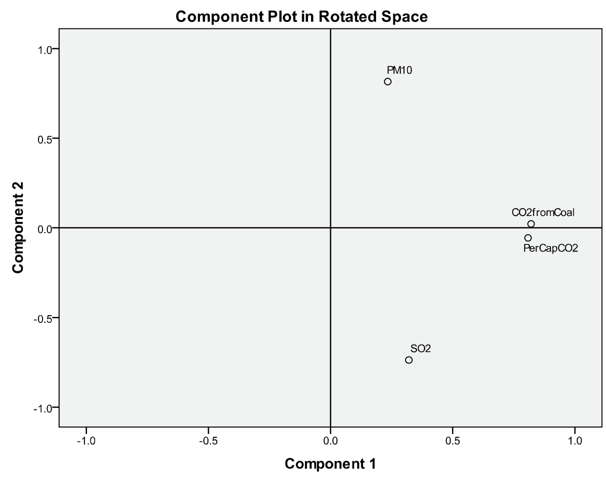

Fig. 30. In developing Africa

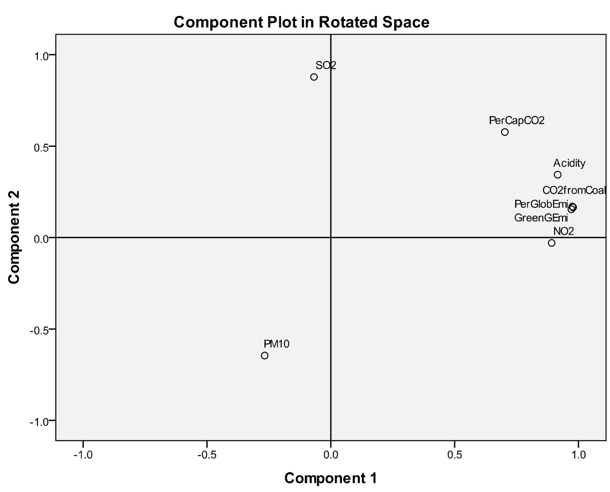

Fig. 31. In developed America

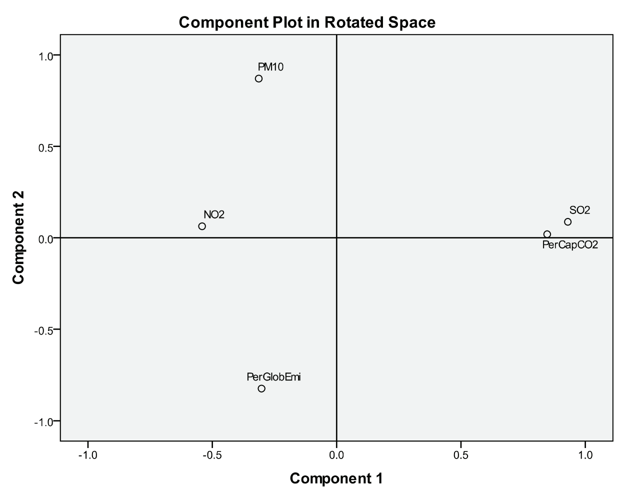

Fig. 32. In developing America

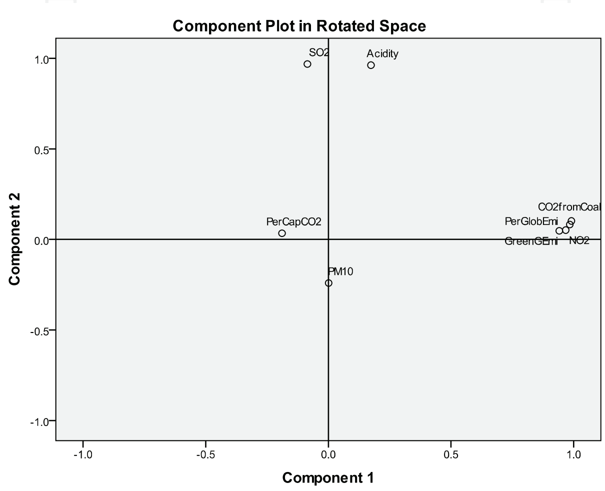

Fig. 33. In developed Asia

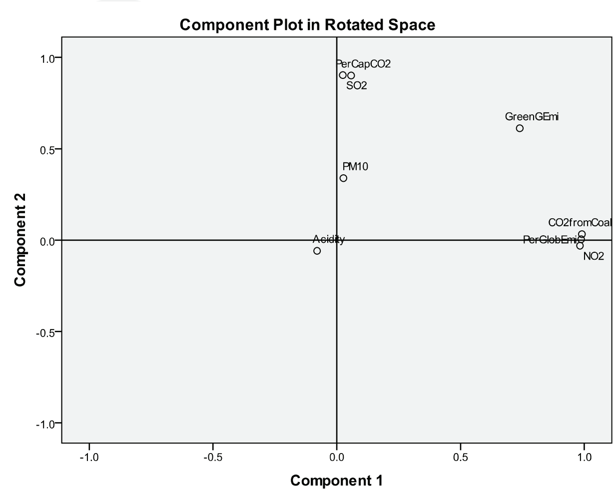

Fig. 34. In developing Asia

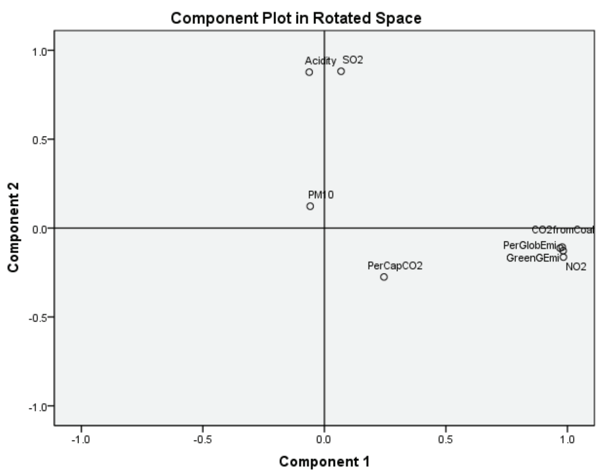

Fig. 35. In developed Europe

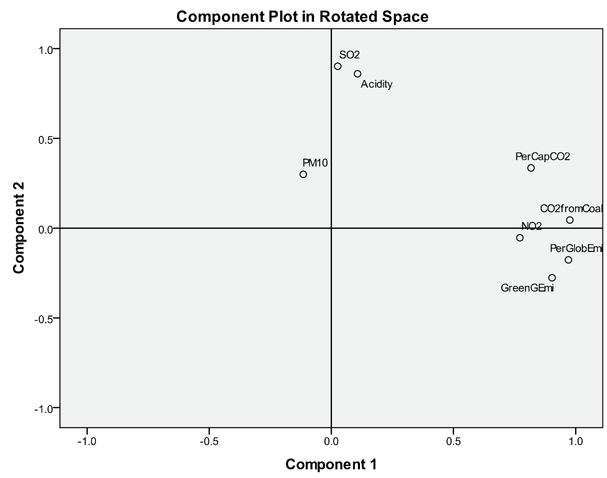

Fig. 36. In developing Europe

The nations in all continents should perhaps collectively create and implement a policy to restrict the coal burning as it produces significant amount of CO2 and PM 10 to the air pollutions. The nations should agree to minimize the sulfur dioxide and the emissions. These two commitments would undoubtedly reduce the acidity in the rain. Consequently, the water and land contaminations would significantly reduce in all continents. The world health will improve.

The status of the world health is now not in what is desirable. The nations spend more for the healthy living, if they can afford (see Figures 37 through 44). Most of the nations with higher per capita GDP spend more for healthy living. Notice in general, the impact of air pollutions on the incidences of cancer and tuberculosis is more positive than on the incidence of cardiovascular cases (see Figure 37 through 44) in all continents.

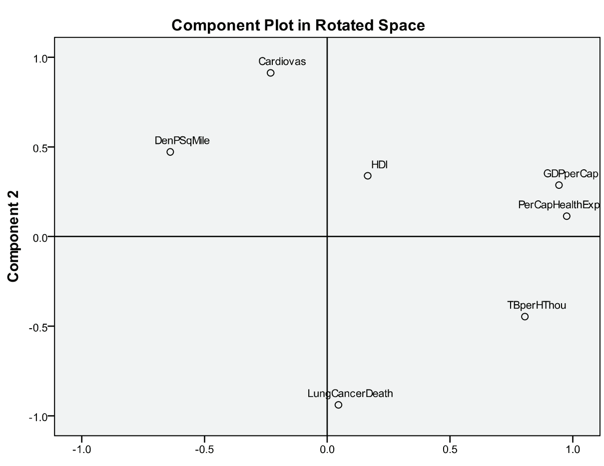

Fig. 37. Health in developed Africa

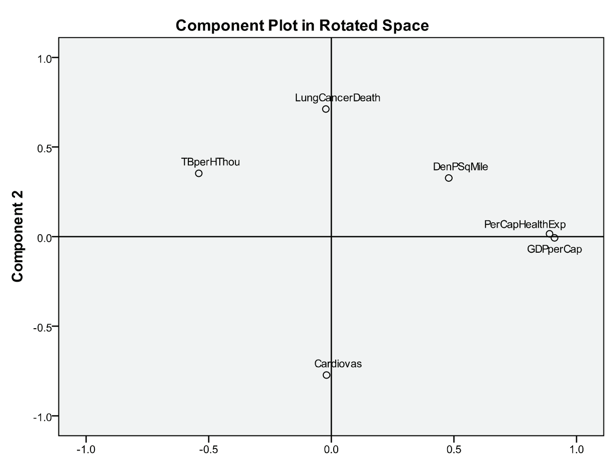

Fig. 38. Health in developing Africa

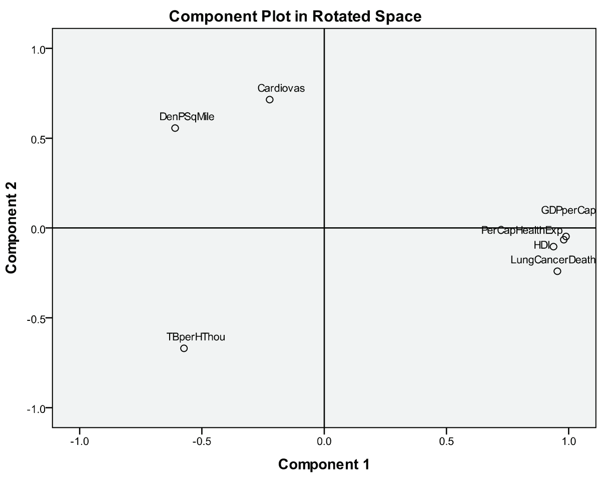

Fig. 39. Health in developed America

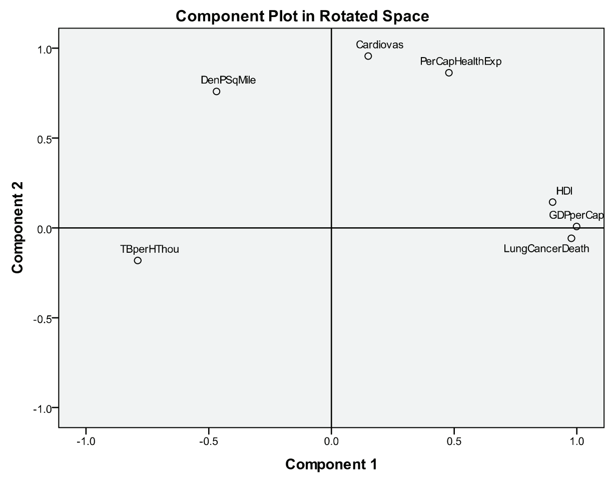

Fig. 40. Health in developing America

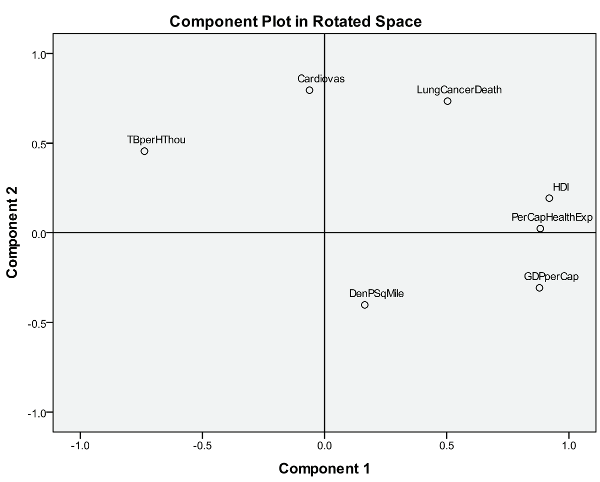

Fig. 41. Health in developed Asia

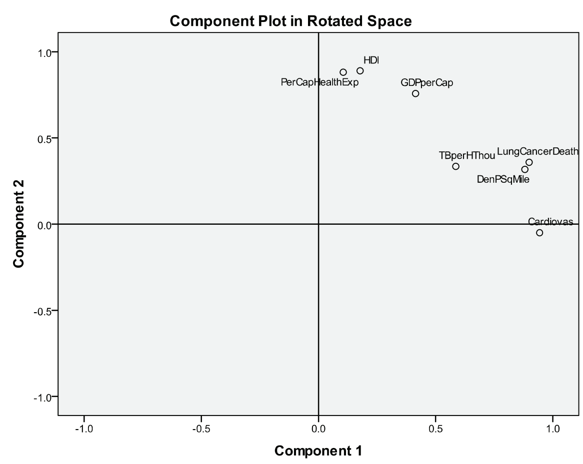

Fig. 42. Health in developing Asia

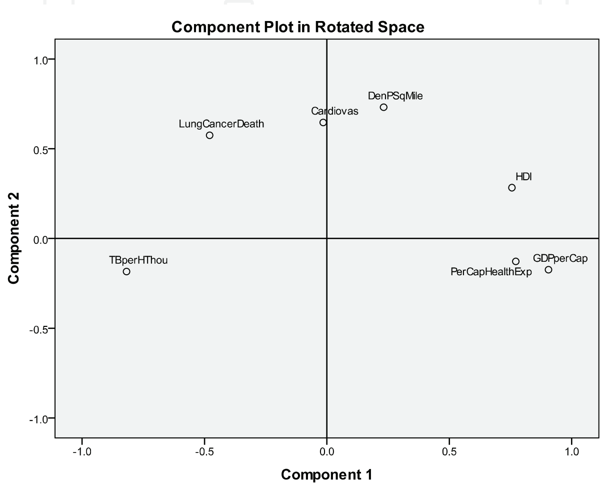

Fig. 43. Health in developed Europe

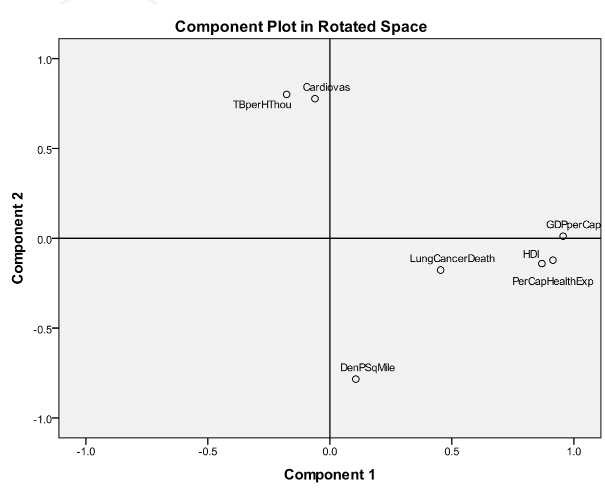

Fig. 44. Health in developing Europe

5. Conclusions

As this chapter pointed out, the carbon dioxide from the coal burning is a serious source of the air pollutions in all continents. A restriction on the coal burning is likely to reduce significantly the CO2 in the air. The abundance of sulfur dioxide and PM 10 in the air is noticed in nations where the petroleum industries related activities are more. The emissions contribute to the air pollutions more in developed than in developing countries. The nitric oxide and the PM 10 in the air are due to agriculture related activities and they are more in developing than in developed countries. Nations with the higher per capita GDP spend more for healthy living than the nations with the low per capita GDP. More restrictive global air pollution policies would help to improve the global public health.

6. Acknowledgement

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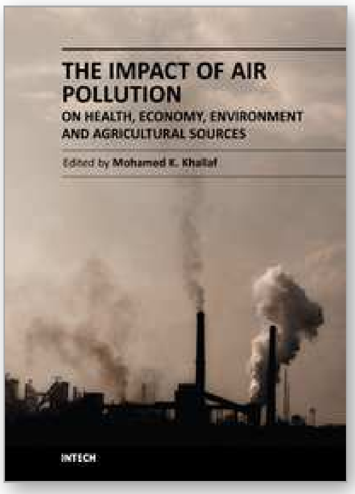

The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources
Edited by Dr. Mohamed Khallaf

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This book aims to strengthen the knowledge base dealing with Air Pollution. The book consists of 21 chapters dealing with Air Pollution and its effects in the fields of Health, Environment, Economy and Agricultural Sources. It is divided into four sections. The first one deals with effect of air pollution on health and human body organs. The second section includes the Impact of air pollution on plants and agricultural sources and methods of resistance. The third section includes environmental changes, geographic and climatic conditions due to air pollution. The fourth section includes case studies concerning of the impact of air pollution in the economy and development goals, such as, indoor air pollution in México, indoor air pollution and millennium development goals in Bangladesh, epidemiologic and economic impact of natural gas on indoor air pollution in Colombia and economic growth and air pollution in Iran during development programs. In this book the authors explain the definition of air pollution, the most important pollutants and their different sources and effects on humans and various fields of life. The authors offer different solutions to the problems resulting from air pollution.