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Section D: General Section

Review Article

Comparing Air Quality Standards in Developed, Developing, and Underdeveloped Nations and Its Relative Analysis with Indian Standards

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ABSTRACT

The fast growing economies in the World, and continued urbanization in countries, have increased the demand for mobility and energy in the region, resulting in high levels of air pollution in cities from both point and non point sources. The World Health Organization estimates that about 500,000 premature deaths per year are caused by air pollution, leaving the urban poor particularly vulnerable since they live in air pollution hotspots having wider exposure to variety of pollutants, which have resulted in pollution related diseases besides low respiratory resistance due to bad nutrition, and lack access to quality health care. However, by initiating air quality management measures, reducing the pollutants at source at various stages of economic development, communities and countries can avoid the severity of air pollution impacts and related costs and attain better air quality.

Key words: Air Pollution / Air Quality Standards / Particulate Matter / Suspended Particles

INTRODUCTION

The integrated approach utilized to set up Air Quality Standards arises after the growing impact of air pollutants, their reactivity, transformation, and pollution caused by these pollutants has been observed or estimated over a period of time. It is because of this very reason that countries need to renew their established air pollution standards time and again. The air quality management systems comprises from the inputs of two factors:

- ***Technical issues (emissions monitoring, modeling, source apportionment, human exposure, emission control approaches, technologies, and databases of air emissions)***
- ***Policy issues (policy, regulations, compliance, and enforcement).***

It is interesting to note that projects and programs tend to be more easily categorized by the type of response towards air pollution (measurement, regulation, and implementation of measures) than by understanding the source of air pollution (transport, industry, and other sources). The ultimate aim of these standards is to recognize variable solutions to address issue of air pollution that may also create positive impacts on long term sustainable development, trans-boundary air pollution, sustainable transport, energy efficiency, and its direct impact on global climate change.

In this paper the comparative study of Air Pollution Standards followed in various countries (developed, developing, and under developed) has been done. These countries include the United States of America, India, China, and Nigeria. The United States being the developed economies, India and China being the two progressive developing economies and Nigeria is one of the oil consumers of Africa and the least developed country. Each of these countries depends heavily on the various resources which not only results in degradation of environment but creates massive amount of emissions leading to high degree of air pollution. If proper steps are not taken towards sustainable development, the air pollution condition in these countries will become uncontrollable. What is response of these countries to the air pollution rendered by the various factors is a matter of great concern for environmentalist because by generating the awareness and policy implementation is not sufficient enough to address the air pollution concerns of these countries as well as world at large.

POLLUTANTS UNDER CONSIDERATION

Some of the pollutants of considerable importance are:

- "Particulate matter," also known as particle pollution or PM, is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. Particulate matter especially fine particles containing microscopic solids or liquid droplets that are so small that they can get deep into the lungs and cause serious health problems. Numerous scientific studies have linked particle pollution exposure to a variety of problems.
- Nitrogen dioxides (NO_2), Sulphur dioxide (SO_2), Oxides of Carbon (CO and CO_2), Ozone (O_3), Hydrogen Sulphide (H_2S), Hydrogen fluoride (HF), Hydrocarbons, Lead (Pb), Mercury (Hg), Cadmium (Cd) particles etc.

ANALYSIS OF AIR QUALITY STANDARDS OF DIFFERENT COUNTRIES

A: The United States: The pollution controls standards in USA are enforced by the Clean Air Act under which, Environment Protection Agency (EPA) establishes Air Quality Standards to protect public health and the environment. The Clean Air Act of 1970 defined six ***criteria pollutants*** and established ambient concentration limits to protect public health. EPA periodically has revised the original concentration limits and methods of measurement, most recently in 1997. All Monitoring sites report data to EPA for these six criteria air pollutants:

- **Carbon Monoxide (CO)**
- **Nitrogen Dioxide (NO_2)**
- **Ozone (O_3)**

- **Sulfur Dioxide (SO_2)**
- **Lead (Pb)**
- **Particulate Matter (PM_{10} and $PM_{2.5}$ where PM_{10} and $PM_{2.5}$ are acronyms for particulate matter consisting of particles smaller than 10 and 2.5 micrometers, respectively.)**

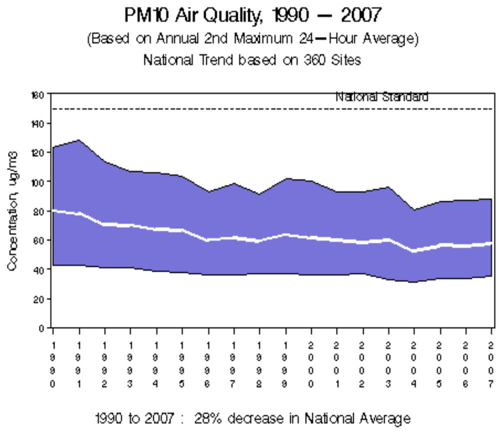
The Clean Air Act, which was last amended in 1990, requires EPA(Environment protection Agency) to set **National Ambient Air Quality Standards** (40 CFR part 50) for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards.

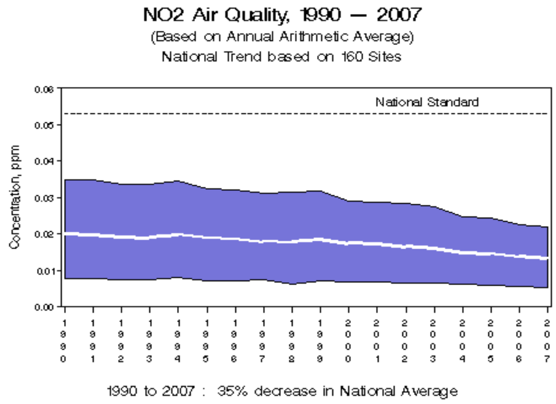
- ***Primary standards*** set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.
- ***Secondary standards*** set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. Table mentioned below gives a clear picture of ambient air quality standards.

National Ambient Air Quality Standards

	Primary Standards		Secondary Standards	
Pollutant	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide (CO)	09 ppm (10 mg/m^3)	8-hour	None	
	35 ppm (40 mg/m^3)	1-hour		
Lead (Pb)	0.15 $\mu g/m^3$	Rolling 3-Month Average	Same as Primary	
	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary	
Nitrogen Dioxide (NO_2)	0.053 ppm (100 $\mu g/m^3$)	Annual (Arithmetic Mean)	Same as Primary	
Particulate Matter (PM_{10})	150 $\mu g/m^3$	24-hour	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual (Arithmetic Mean)	Same as Primary	
	35 $\mu g/m^3$	24-hour	Same as Primary	
Ozone (O_3)	0.075 ppm (2008 std)	8-hour	Same as Primary	
	0.08 ppm (1997 std)	8-hour	Same as Primary	
	0.12 ppm	1-hour (Applies only in limited areas)	Same as Primary	
Sulfur Dioxide (SO_2)	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm (1300 $\mu g/m^3$)	3-hour
	0.14 ppm	24-hour		

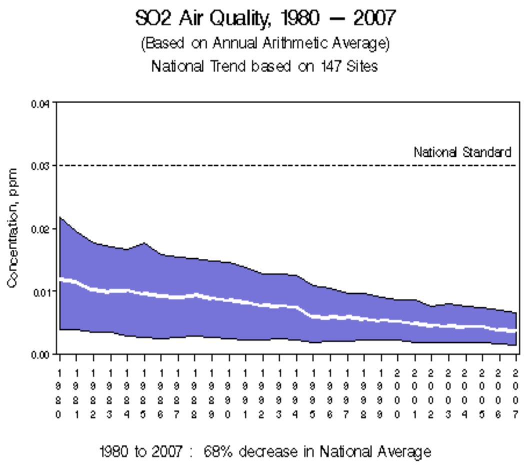
EPA has decided to retain the existing 24-hour PM_{10} standard of 150 $\mu g/m^3$. Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the Agency has revoked the annual PM_{10} standard.

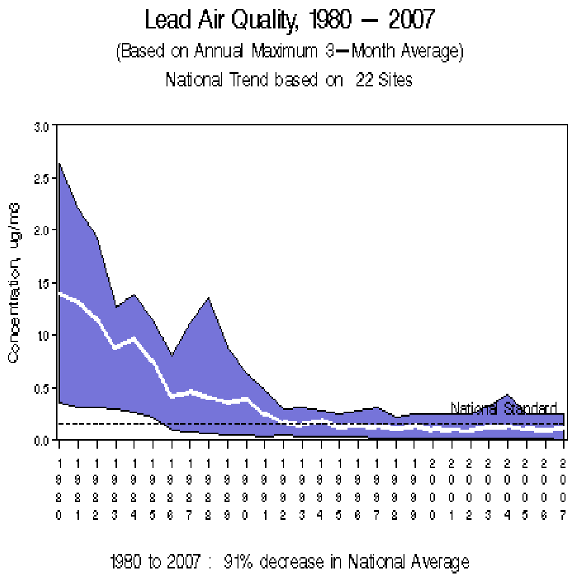




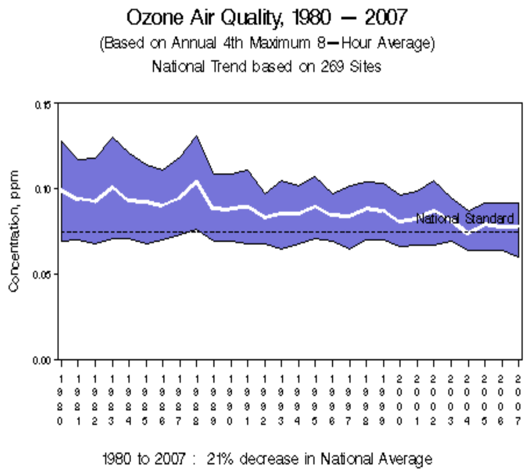
Particulate matter 10 trends in the US[1]

The dark band shows the distribution of air pollution levels among the trend sites, displaying the middle 80%. The white line represents the average among all the trend sites. 90% of sites have concentrations below the top line, while ten percent of sites have concentrations below the bottom line. It can be seen that the particulate matter in air since 1997 to 2007 has been always below the EPA standards. There has been a decrease in the National average emission of particulate matter by 28%. EPA's National Ambient Air Quality Standard for nitrogen dioxide is the annual arithmetic mean concentration of 0.053 parts per million (ppm).





[1] http://www.epa.gov/air/airtrends/aqi_info.html



Note: The graphs to be interpreted in the same way as discussed earlier.

India

Table 1: National Ambient Air Quality Standards[2]

Pollutant	Time Weighted Average	Concentration in Ambient Air		
		Industrial Area	Residential, Rural and other	Sensitive Area
Sulphur Dioxide (SO_2)	Annual 24 hours	80 $\mu g/m^3$ 120 $\mu g/m^3$	60 $\mu g/m^3$ 80 $\mu g/m^3$	15 $\mu g/m^3$ 30 $\mu g/m^3$
Nitrogen Oxides (NO_2)	Annual 24 hours	80 $\mu g/m^3$ 120 $\mu g/m^3$	60 $\mu g/m^3$ 80 $\mu g/m^3$	15 $\mu g/m^3$ 30 $\mu g/m^3$
Suspended Particulate Matter (SPM)	Annual 24 hours	360 $\mu g/m^3$ 500 $\mu g/m^3$	140 $\mu g/m^3$ 200 $\mu g/m^3$	70 $\mu g/m^3$ 100 $\mu g/m^3$
Respirable [3] Particulate Matter (RPM)	Annual 24 hours	120 $\mu g/m^3$ 150 $\mu g/m^3$	60 $\mu g/m^3$ 100 $\mu g/m^3$	50 $\mu g/m^3$ 75 $\mu g/m^3$
Lead (Pb)	Annual 24 hours	1.0 $\mu g/m^3$ 1.5 $\mu g/m^3$	0.75 $\mu g/m^3$ 1.00 $\mu g/m^3$	0.50 $\mu g/m^3$ 0.75 $\mu g/m^3$
Carbon Monoxide (CO)	8 hours 1 hour	5.0 $\mu g/m^3$ 10.0 $\mu g/m^3$	2.0 $\mu g/m^3$ 4.0 $\mu g/m^3$	1.0 $\mu g/m^3$ 2.0 $\mu g/m^3$

Table 2: Levels of Sulphur Dioxide (SO_2) in Atmosphere of the 3 Mega Cities:

City	Sulfur Dioxide (SO_2) Level (in $\mu g/m^3$) 2006	Level
Chennai	05	Low
Mumbai	26	Low
Delhi	14	Low

(Low Level - 0-40 $\mu g/m^3$, Moderate Level - 41-80 $\mu g/m^3$, High Level - 81-120 $\mu g/m^3$, Very High Level > 120 $\mu g/m^3$)

[2] Ministry of Environment and Forests, Government of India Notification
[3] Particle Size less than 10 µm

Table 3: Levels of Nitrogen Dioxide (NO_2) in atmosphere of the 3 Mega Cities:

City	Nitrogen Dioxide (NO_2) Level(in µg/m^3) 2006	Level
Chennai	19	Low
Mumbai	37	Low
Delhi	58	Moderate

(Low Level - 0-40 µg/m^3, Moderate Level - 41-80 µg/m^3, High Level - 81-120 µg/m^3 , Very High Level > 120 µg/m^3)

Table 4: Levels of Respirable Dust in atmosphere of the 3 Mega Cities:

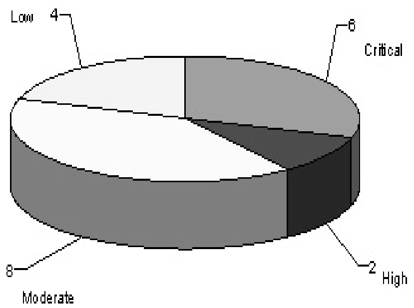
City	Respirable Dust level (in µg/m^3) 2006	Level
Chennai	42	Low
Mumbai	131	High
Delhi	178	Very High

(Low Level - 0-50 µg/m^3, Moderate Level - 51-100 µg/m^3, High Level - 101-150 µg/m^3, Very High Level > 150 µg/m^3)

Table 5: Annual Mean Concentration Range (µg/m^3)

Pollution Level	Industrial (I) RSPM Levels	Residential (R) RSPM Levels
Low (L)	0-60	0-30
Moderate (M)	60-120	30-60
High (H)	120-180	60-90
Critical (C)	>180	>90

Charts depicting the distribution of Indian cities under the various RSPM levels:



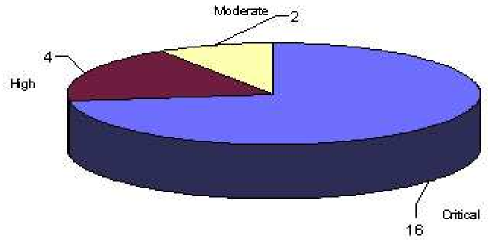


Fig. 6.7 Number of Cities (Res. Areas) with Critical, High and Moderate RSPM Levels :

Number of Cities / Industrial areas with Critical, High, Moderate, and Low RSPM Levels

Table 6: List of Non Attainment Cities in India

Pollutant of Concern	No. of Non Attainment Cities
RSPM (Respirable Suspended Particulate Matter)	61
SPM (Suspended Particulate Matter)	64
Nitrogen Dioxide (NO_2)	09
Sulphur Dioxide (SO_2)	01

CHINA

Standards Prescribed by Ministry of Environment[4]

Pollutant	Class I	Class II	Class III
Sulphur Dioxide (SO_2)	0.02	0.06	0.1
PM_{10}	0.05	0.15	0.25
Nitrogen Dioxide (NO_2)	0.08	0.12	0.12
Ozone (O_3)	0.12	0.16	0.20

Figures in ppm

- Class I standards apply to specially protected areas like national conservation areas, scenic spots and historic sites
- Class II Standards apply to residential areas, mixed residential-commercial areas, cultural, industrial and rural areas
- Class III standards apply to special industrial areas.

Comparison of Sulphur Dioxide (SO_2) - Grade in Comparable Cities

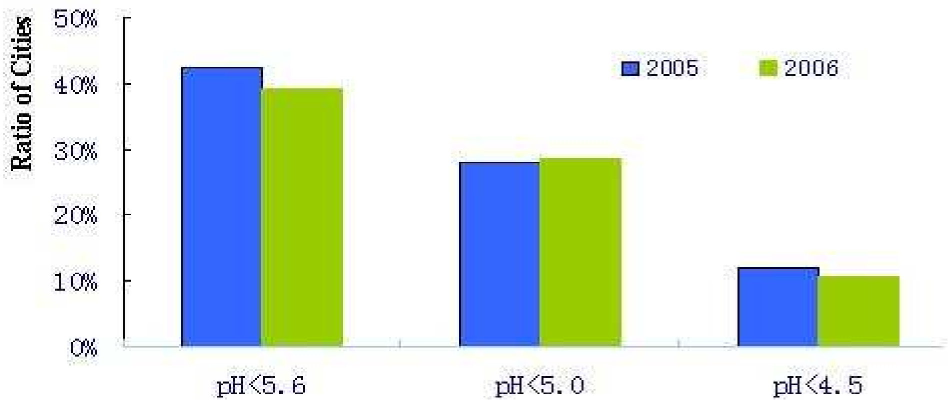
Grade of Air Quality	2006	2005
At or better than Grade II (up to standard), %	62.8	59.5
Grade III, %	31.9	35
Worse than Grade III, %	5.3	5.5

[4] http://www.cleanairnet.org/ssa/1414/article-36220.html

Comparison of Nitrogen Dioxide (NO_2) - Grade in Comparable Cities

Grade of Air Quality	2006	2005
At or better than Grade II (up to standard), %	81.7	77.4
Grade III, %	13.9	16.1
Worse than Grade III, %	4.4	6.5

Acid Rain- Its pH



Nigeria

The issue of poor urban air quality in Sub-Saharan Africa is emerging as a key threat to the health, the environment and the quality of life of millions of people as cities deal with the combined. The pollution standards followed by Nigeria are the same as those prescribed by the WHO. With a national consumption of 25 million litres and a 75% emission rate of lead as lead particulate, it could be deduced that upto 05 tonnes per day or 1,800 tonnes of lead per annum.

Most motorized trips (81%) are made on two-wheeler taxi-motors that carry no more than one passenger apiece. Because of the low carrying capacity of mopeds, the 1.4 million motorized trips generate over 04 million vehicle kms traveled each day. An analysis of the registered vehicle pool shows that the majority of vehicles are over 10 years old with an average of 12.5 years. A high number of two wheeler vehicles are also in circulation. It is more difficult to estimate their number and cylinders, as registration is not mandatory for them.

The places as well as the measuring periods were chosen in order to, afterwards, distinguish the role of transport in global pollution. The results indicated high pollution at certain intersections.

- CO concentration reached 18mg/Nm^3 (almost double the norm).The value level obtained for HCs indicates a crucial problem for this pollutant.
- Pollution by NO_2 remains within acceptable limits (concentration of 50µg/Nm^3).
- Concentration in SO_2 is less than the detection limits of the measuring equipment.

- Finally, ozone concentration is high and could exceed European limits.

Consumption of oil represents 62% of the country's oil expenses, four times more than the industrial sector. Moreover it has to be noted that transport mainly has a very local impact on air quality. This is why atmospheric pollution along major highways is almost all caused by transport. This was confirmed from results of various analyses: Carbon monoxide (CO) concentration level outside of the city was 10 times less than at the main intersections.

Other Sources of Lead Pollution in Nigeria

Because lead is cheap and useful, it has very many useful applications in both industrial and consumer products. The main sources of lead pollution in Nigeria besides gasoline[5] include:

- Lead Mining and Smelting
- Paints
- Piping Fixtures and Solder
- Lead based Batteries
- Hobbies and Recreational Activities that use lead
- A large increase in emissions and in concentration of different pollutants in the air is noted:
- Emissions will double on average by the year 2010
- The cost of air pollution therefore reaches approx 1.2% of the country's GDP[6]

Regarding impact upon air quality, Hydrocarbon concentration is higher in certain places than 2000 $\mu g/Nm^3$ and some problems pertaining to standards respect for NO_x were observed. Furthermore, a build up of concentration in lead is noted for 10% of the network with a maximum of 13 $\mu g/Nm^3$ which is approximately 06 times more than the acceptable level.

Analysis of the Air Quality of the Countries

The pollutants such as Particulate Matter (PM) and Sulphur dioxide (SO_2) show an all time low level of their presence in the atmosphere and the level of these pollutants is much lower than the standards. This could be attributed to the higher land area of the US as compared to its population i.e. its population density.

For India levels of Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) are within the prescribed National Ambient Air Quality Standards. A decreasing trend has been observed in Sulphur dioxide levels in residential areas of cities like Delhi, Mumbai, Lucknow, and Bhopal etc., during last few years. The decreasing trend in Sulphur dioxide and nitrogen dioxide levels may be due to various measures taken such as reduction of Sulphur in diesel etc. and use of LPG instead of coal as domestic fuel. Also, conversion of diesel vehicles to CNG may have contributed to reduction in these levels.

- However, levels of lead and ground level ozone have been always high which is common for all.

- Lead is extensively used in industries like paints, varnishes, packaging etc. and also come out through vehicular emission which does not use unleaded petrol. It is most in case of Nigeria, given its heavy dependence on mopeds which aren't regulated.

- Ozone is not emitted directly; it forms by chemical reactions of organic compounds with nitrogen oxides in the air, mediated by sunlight.

- Levels of Nitrogen dioxide (NO_2) have reported to be low as it undergoes various reactions with other substances to ultimately form some other pollutant. E.g. Ammonia reacts with nitric acid and sulfuric acids in the atmosphere to form fine particulate matter, while ozone is a resultant of reactions of nitrogen dioxide in presence of sunlight.

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[5] Earth Summit Watch '*The Global Phase out of Leaded Gasoline: A successful Initiative*

[6] www.worldbank.org/afr/ssatp

- The levels of RSPM exceed the prescribed National Ambient Air Quality Standards in most of the cities. One of the major sources of high RSPM levels is vehicles. The vehicle population is increasing exponentially in many cities. This is the single major factor for high RSPM levels.
- The reason for high particulate matter levels may be vehicles, engines, small scale industries, biomass incineration, boilers and emission from power plants, re-suspension of traffic dust, commercial and domestic use of fuels, etc.
- The levels of SPM exceed the prescribed National Ambient Air Quality Standards in most of the cities. Trend in annual average concentration of SPM is fluctuating in many cities.
- Lower levels of RSPM and SPM were observed during monsoon months possibly due to wet deposition. Higher levels of RSPM were observed during winter months possibly due to lower mixing heights and more calm conditions.
- Chinese economy is a flourishing one; moreover its population is also high.
- The main sources of pollution are the multitude of industries and vehicles which keeps increasing every year to come at par with the population, the growing standards of the people and the upsurge of China as the fastest growing economy in the World. It is evident that such an exponential development comes at the cost of environment, though Chinese government takes stringent measures to ensure that the standards are followed. The issue of poor urban air quality in Sub-Saharan Africa is emerging as a key threat to the health, the environment and the quality of life of millions of people as cities deal with the combined effects of rapid economic activity, urbanization and motorization. In spite of this, most countries in the region still lack systems to assess air pollution levels as well as enforceable air quality and emission standards. The air quality over Nigerian cities is abnormally high due to the presence of large numbers of industrial and transportation concerns operating with minimal regards for the environment. Equally, the large number of old and poorly maintained vehicles on the streets compound this problem.

CONCLUSION

It is concluded that the pollution standards followed by these countries are more or less same. They all confirm to the air pollution standards set by the WHO. However, the levels of pollution measured for each country come out to be different. These not arises due to their geographical conditions and economy but many other factors. An acceptable air quality of any country depends upon the cumulative approaches of the government, the industrial groups, NGOs, community groups, International organisations, research institutions, public awareness and judiciary. It may be fall back on part of one or more of these factors that ultimately the environment bears the brunt of the exponential urbanization and development. An unhealthy environment is not only violative of peoples' basic right to health but also disastrous to the generations to come.

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