Presidential address

Air pollution: a case study of environmental pollution.

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The very survival of innumerable species of living forms on planet earth has never been more at risk than now, as we stand on the threshold of the new millennium. Survival of human beings is only another facet of the ability of living beings to survive on earth and not a unique right of humankind. With globalization no more do we live in isolation, immune from the threats to life and survival through environmental damage. When survival of human beings is at stake, it behoves us to be very much aware of the situation regarding environmental pollution globally, in the region and specially in Sri Lanka.

All along human beings have lived in close harmony with the environment. They have cared for it, tried to protect it, prevented its damage and ensured that it would sustain future generations. For, "Whatever befalls the earth, befalls the sons of the earth. Man did not weave the web of life. He is merely a strand in it. Whatever he does to the web, he does to himself" a remark made by none other than the great Red Indian chief Seatle.

In the short time available to me I propose to place before you a very brief overview of the complex picture of environmental pollution and health using atmospheric pollution as a case study under the headings of

1. Air pollutants
2. Methodological issues in assessments
3. Health effects
4. Strategies for prevention and control
5. Health benefits of such efforts

1. Air pollutants: causes, sources and constituents

Causes

The damage and degradation of the environment is directly related to population growth, limited resources available on earth for the ever increasing population, lack of foresight and concern for the environment. Underlying all these is ignorance, failure to implement rules and regulations, and wanton and, at times, even callous disregard for the environment and its preservation in the quest for economic gains.

Air is considered to be polluted when it contains certain substances in concentrations high enough and for duration long enough to cause harm or undesirable effects. The effects of air pollution arise when populations are exposed to pollutants at levels in excess of the recommended threshold limit values (TLV).

Table 1: Energy sources and consumers in Sri Lanka

Primary energy sources	%
Biomass	71
Fossil fuel	19
Hydroelectricity	10
All	100
Principal consumers of energy by sector	%
Household	67
Industry	16
Transport	15
Commercial	1
Agriculture	1
All	100

Sources

Air pollutants are either natural or man-made or

Table 2: Change in Sri Lanka Energy Balance 1990-1999

Sector	Electricity (GWh)		Fossil fuel (600 M.T)		Firewood (000 MT)	
	1990	1999	1990	1999	1990	1999
Agriculture	-	-	-	-	-	-
Industry	1054.3	1512.70	29.1	376.1	1528	1710
Transport	-	-	746.69	1484.6	1484.56	-
Household Commercial	1340.70	3356.90	197.41	363.2	8110	8240
Total	2395	4869.60	973.2	2223.9	9638.00	9950

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anthropogenic. Earthquakes, volcanic eruptions, forest fires, sea erosion, landslides, air borne particles from plants such as pollen are some of the natural sources. The principal source of anthropogenic pollutants is energy production. The primary sources of energy in Sri Lanka are, biomass (71%), that is fuel wood and agricultural waste; fossil fuel (19%) mainly fuel oils and their products; and hydroelectricity (10%) (Table 1). The principal consumers of energy are household (70%), industry (16%), and the transport sector (15%), with the commercial and agricultural sectors accounting for only 2%.

Perusal of the change in energy balance for Sri Lanka from 1990 to 1999 (Table 2) shows that electricity, mainly for household use and in industry to a lesser extent, and fossil fuels in the transport sector, have shown the largest increase, while the increase of biomass for energy production has been relatively small.

Many authors have identified vehicular emissions as the major source of air pollutants in urban areas. The growth pattern of the total operated fleet in the past shows that the number of diesel driven vehicles has increased at an average rate of 6% per annum compared with the petrol driven ones at 4% per annum. According to data available at Ceylon Petroleum Corporation the average annual growth of consumption of petrol has been 3.5% and of diesel 10%, for the period 1991-1996 (Table 3).

Constituents

The air pollutants arising from energy use are

- suspended particulate matter (SPM)
- oxides of carbon (CO, CO2), carbon monoxide and dioxide

  nitrogen (NOx)

  sulphur (SOx)
- hydrocarbons
- lead

This is also enriched with micro-organisms and pesticides in certain areas. Suspended particulate matter (SPM) thus has smoke, dust, poycyclic aromatic amines, heavy metals, pesticides and aerosols derived both from natural and anthropogenic sources and is considered as the primary health damaging pollutant. The fine SPM (PM10) are respirable dust which enters the alveoli of the lungs and are generally liberated from anthropogenic sources while the coarse SPM are more likely to arise from natural sources and also contains sand and dust.

These major pollutants react in the atmosphere to form a range of undesired secondary pollutants such as ozone, nitric acid, sulphuric acids and their precipitates.

Meteorological parameters such as wind direction, wind speed, solar radiation, barometric pressure, humidity, rain fall and ambient temperature also play an important role in

Table 3: Consumption of fuel oil in Sri Lanka 1991-96 (Metric tons)

Fuel oil	1991	1992	1993	1994	1995	1996
Auto diesel	588107	627505	688007	750217	816394	951675
Gasoline	159336	164579	172720	183720	191691	198289

Table 4 : Estimated emissions from petroleum combustion (Metric tons)

Emission	Transport	Industry	Power and Energy	Household
SOx	455	9791	107	113
NOx	5928	1244	20	77
Hydrocarbons	38364	67	0.2	13
CO	199736	98	1	8

Table 5: Estimated % emissions from petroleum combustion sources in Sri Lanka

Emissions	Transport	Industry	Household	Other
SOx	45	44	3	8
NOx	45	13	5	6
Hydrocarbon	45	2	6	3
CO	45	0.5	0.5	1
SPM	59	14	21	6

Table 6 : Annual lead pollution from transport sector in Sri Lanka and in Colombo Urban Area (CUA)

Year	1991	1992	1993	1994	1995	1996	1997	2000	2005	2010
CUA	34.3	36.00	38.4	40.4	49.5	52.7	55.7	67	86.2	105.7
Sri Lanka	76.2	81.3	85.3	89.8	110	117.2	123.7	148.8	191.5	234.9

Table 7 : Trends of chronic respiratory disease in the Colombo district

Disease	Year			
	1985	1990	1995	2000
Bronchitis	110.9	288.6	154.6	226.5
Pneumonia	74.3	211	80	111
Asthma	172.3	754.7	721.7	542.8

dispersion, dilution and transformation of air pollutants in the ambient air.

The source apportionment to different energy sources is not easy and emission inventories have been developed using different formulae.

Table 4 shows the estimated emissions of different pollutants from petroleum combustion in Sri Lanka with the transport sector being responsible for a huge proportion of CO and HC, mainly from diesel. The % contribution of each pollutant from petroleum combustion by sectoral use is given in Table 5.

The release of inorganic lead from leaded petrol into the ambient air has contributed to gradually increasing levels of lead (Table 6) and is projected to continue to do so unabated in the future unless steps are taken to take leaded petrol off the market, the release of lead will be very high.

2. Methodological issues in assessment of health effects

There is evidence that air pollution has far reaching direct effects on human health although there is no simple, direct, uncomplicated relationship between them.

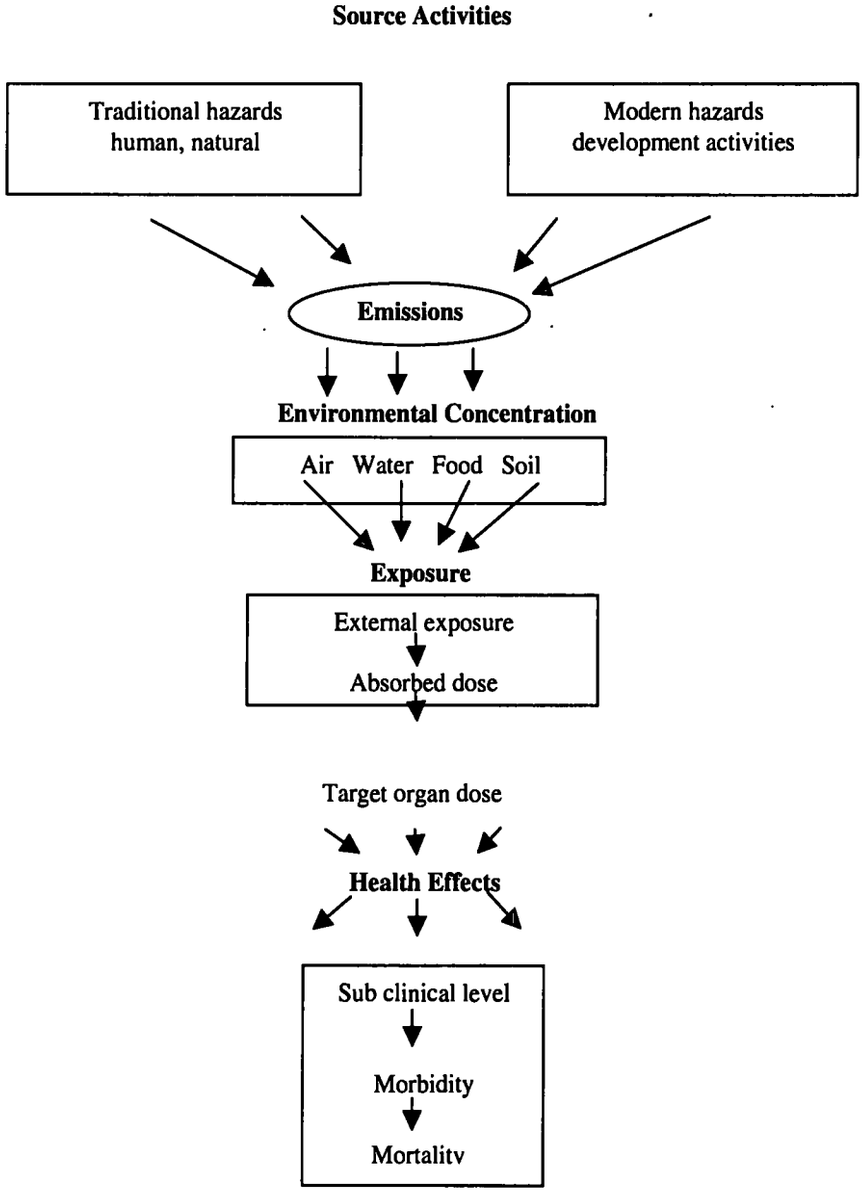
Evidence for health effects have come from epidemiological studies and, includes, in hierarchical order of scientific credibility and rigour, case studies, evidence from mass exposure, correlational or ecological studies, analytical including case control and cohort studies and data linkage studies with modeling.

Several well known episodes of mass exposure of communities to sudden and high levels of pollutants and resultant health effects have been documented. The Meuse Valley episode in Belgium in 1930 with 63 deaths; Donora, Pennsylvania in USA in 1948 resulting in 20 deaths, and the famous London SMOGS of 1952 and 1962 with excess of 4000 and 750 deaths respectively, clearly demonstrated the excess morbidity and mortality associated with these exposures.

Most recent studies linking health with air pollutants have applied multivariate methods such as Poisson models that address major potential confounders giving more accurate estimates of risk after adjusting for other factors. In such models the value of the expected number of health effects is modified as an exponential function of explanatory variables (exposure variables), the changes in the number of health effects with change in the ambient concentrations of pollutants and carry out space / time modeling.

The World Health Organization has put forward a conceptual model which illustrate both traditional hazards of poor sanitation and modern hazards of development that contribute to health effects through the emission of pollutants exceeding TLVs and accepted standards. The routes of exposure and the health effects are also included in the model.

Figure 1 : The environmental health hazard Pathway



World Health Organization, 1996

3. Health Effects

The health effects of air pollutants are both direct and indirect. The direct effects often shorten the lifespan and excess mortality; result in specific health problems and diseases; and non specific symptoms.

The long term and indirect impacts on health from ambient air pollution arise firstly, from greenhouse gases (GHGs) which are made up of CO2, CFCs, hydrocarbons compounded by deforestation. These effectively restrict the heat from being disseminated to the atmosphere and the stratosphere and thus cause global warming.

The second problem is that of stratospheric ozone depletion.

It is well known that 20% of the world's population living in countries with lowest per capita emissions of fossil fuel CO2 contributed to just 2% of all CO2 emissions, and 20% of the worlds' population living in countries with the

highest per capita fossil fuel CO2 emissions contributed to a massive two thirds (63%) worlds' total emissions. The United States which has expressed its opposition to the recommended cuts of GHG emissions, has only 4.6% of the worlds' population and produces one fourth (25%) of total GHG emissions. This itself gives a per capita emission level, 5 times the level scientists believe the atmosphere can support without significant global warming.

The second problem, that of stratospheric ozone depletion have global health effects of, a rising levels of solar radiation reaching the earth and the resulting excess cases of skin cancer, cataract, heat strokes etc.

The climate change from GHGs also will result in adverse health effects of global warming both directly and indirectly through their effects on damage to ecosystems resulting effects on fauna and flora which are far too complicated to discuss here.

Figure 2 (page 9a) shows the Southern hemisphere with the literal, 'hole' in the ozone layer, at less than the world average of 300 Dobsun units.

The hole which had expanded to a large area in 2001, seem to show a slight reduction in size from the data available in 2002 (Figure 3, page 9a). The shaded area which is a smaller area has been the average size of the hole from 1972-1999.

The scope of human health effects of air pollution goes beyond the respiratory system. The diseases in figure 4 (page 5) displays effects with acceptable evidence of association with air pollution in a large number of cities (over 20) across the world and have been used extensively in standard setting and has been put forward by USEPA in 1999.

Figure 4: Scope of human health effects of air pollution

Quantifiable health effects	Suspected health effects
Mortality (elder)	Induction of asthma
Mortality (infant)	Fetus/child developmental effects
Neonatal mortality	Increased airway responsiveness
Bronchitis: chronic and acute	Nonbronchitis chronic respiratory diseases
Increased asthma attacks	Cancer
Hospital admissions for respiratory diseases	Lung cancer
Respiratory symptoms	Behavioural effects (e.g. learning disabilities)
Emergency room visits for asthma	Neurological disorders
Moderate or severe asthma	Exacerbation of allergies
Lower respiratory tract illness	Altered host defense mechanisms (e.g. susceptibility to respiratory infections)
Upper respiratory tract illness	Respiratory cell damage
Days of work loss	Decreased time to onset of angina
Cardiovascular hospital admissions	Morphological changes in the lungs

Table 8: TSPM and RD (mg/m3) by use of firewood

Pollutant (mg/	Cooking fuel	
	Firewood	Non firewood
TSPM (Total suspended particulate matter0	0.606	0.245
RD (Respirable dust0	2.097	1.97
% of households with RD exceeding standard*	84%	595

(* Standard mg/m3: TSPM – 0.5; RD – 0.1.0.15)

Table 9 : Blood lead levels by age

Age (Years)	Mean blood lead levels (microg/dl) and (SD)		
	Borella	Dehiwala	Kandy
	Senanayaka et al 2001	Weerasuriya and Dissanayaka, 1979	
1-5	4.3 (1.9)	4.85 (1.45)	2.37 (0.37)
>5-10	5.5 :(1.3)	8.92 (0.75)	2.98 (0.66)
>10-15	6.7 : (1.8)	-	3.24 (0.93)

Sri Lankan Scenario

Respiratory diseases have always been among the first two causes of hospital admission, in Sri Lanka and the trend has not shown an appreciable decline. They have accounted for approximately 10% of total hospital admissions each year.

The success achieved for reducing morbidity from respiratory diseases has been for those diseases for which an effective immunization has been available. The decline in the incidence of diphtheria, whooping cough, and measles is very evident. However, there has been a concurrent increase in other respiratory diseases. This is very evident for bronchial asthma, and bronchitis as well as for pneumonia, upper respiratory diseases.

There is no doubt that the predominant effects of energy production is in the Colombo Urban area and the district where two thirds of the population is urban, population density 3084/sq km (Sri Lanka 273), accounts for >60% of manufacturing industries, and 60% of the registered vehicles and also houses both Sri Lanka's diesel power plants. Thus, the occurrence of respiratory diseases in the Colombo District would give a more relevant indicator of the effects of pollutants than any other part of Sri Lanka.

The sharp increase in trends for asthma as well as other common respiratory diseases in the Colombo district is obvious (Table 7).

A few studies have attempted to correlate air pollutants and reported diseases. Exposure to air pollutants have been based on indoor exposures.

Relationship between ambient air levels of SO_2 and NO_2 and admissions for emergency treatment for wheezing in children under 12 years has been looked at by Senanayake et all (2001) for a one year period from 1 July 98 to 30 June 1999. This study showed a significant relationship between rates of emergency treatment for asthma and levels of SO_2 and NO_2.

Air pollutants from cooking too contribute to ambient air pollution. Domestic setting gives a better scope for studies to assess the relationship between common air pollutants and health effects.

A community based comparative study of respiratory diseases and symptoms using the validated MRC respiratory questionnaire, and exposure to pollutants was carried out in 397 semi-urban households by Seneviratne et al in 1999. The study population comprised 604

children < 10 years of age and 130 women > 40 years of age.

The only identified significant risk factor of respiratory symptoms after adjusting for confounding factors using multiple logistic regression analysis was use of fire wood for cooking (OR=1.61; 95% CI=1.3-2.53). The risk of respiratory symptoms was one and a half times that of a women not exposed to firewood. Of the households surveyed, 45.3% had at least one person with respiratory symptoms. Mean differences between expected and observed PEFR among women cooking with firewood compared with those using other types of fuel was not significant.

The percentage of households using firewood where total suspended particulates in excess of WHO recommended standard was 84% compared with only 54% of households where firewood was not being used (Table 8).

Finer respirable dust (RD) too exceeded the recommended value in households both using and not using firewood. The % of houses with RD in excess of expected was significantly higher for households that used firewood for cooking.

Many studies have highlighted the problem of lead in the environment. A study carried out in 50 randomly selected children under 15years of age living in Borella within 0.5 km. have given some indication of blood lead levels Table 9.

In Borella, 6% children had lead levels of 10 microgr per dl or above, in excess of blood lead level at which environmental intervention is recommended for children. In the children from Dehiwala fairly high mean lead levels have been found.

Global scenario

Quantification air pollutants present in the ambient air on a regular basis has its origin in the first conference on environment held as far back as 1972 in Sweden organized by the World Health Organization. This gave birth to the United Nations Environmental Programme (UNEP) and the GEMS/AIR, the network of Global Environmental Monitoring Systems. Since then, monitoring of common air pollutants has been carried out for nearly 30 years and nearly 50 countries are involved in collecting high quality, comprehensive, and comparable data through out the world. The objective is to monitor and assess urban air quality on a global scale. It aims to provide comprehensive and quality data for rational air quality management and to interpret information for abatement strategy.

Mitigation efforts

Health related environmental control programmes are a major necessity. Some efforts have been made at international and national levels.

Global agreements on environment and health

There have been many Conferences and summits to highlight issues and plan and implement programmes on these issues. All these require global agreement, acceptance and cooperation of member countries. The more important and directly related ones are

1. Unite Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro, Brazil in 1992, the so called Earth Summit.
2. Agenda 21 of the above is the basis for action by the international community to integrate environment and development
3. Habitat conferences on 7th of October each year.
4. RIO+10, The World Summit on Sustainable Development, 10 years after Earth Summit, held in Johannesburg from 27 August to 4th September 2002 to examine efforts made to define and implement strategies sustainable development
5. Kyoto Protocol -1997 the Convention of Climate Change to commit 38 industrial countries to cut their national emissions of GHGs by an average of 5.2% between 1990 to 2010.
6. Montreal Protocol embodies the Convention to protect the stratospheric ozone layer from destruction by human induced emissions of chlorofluorocarbons. We are aware that in Sri Lanka the CFCs from refrigerators have already been phased out.

However, unless action is taken, the emissions from developing countries will become a major

factor early in this century that will require an early response to prevent major pollution.

The Mitigation of GHG and benefits: Experience of four major cities

Is there evidence for effectiveness of mitigation in terms of economic and health benefits?

The studies carried out in Sao Paulo, Brazil, Mexico City, Beijing and New York City with a combined population of 45 million, estimate the health benefits (change) of selected end points that have been projected to occur per million peopled exposed to a given unit of particulate matter and ozone. Coefficients have been developed based on local data, using projected emission patterns and the health impact factors to populations to estimate the potential health benefits using existing readily available technologies that reduce GHGs from fossil fuels.

These measures would reduce fossil fuel emissions of particulates and ozone by 10% and prevent the occurrence of

Premature deaths - 64000 (95% CI: 18,000-116,000)

Chronic bronchitis - 65000 (95% CI: 22,000-108,000)

Person-days of restricted activity or work loss – 37 million (95% CI;27-47 million)

These conservative estimates show the public health benefit of GHG mitigation strategies, of applying cleaner alternative energy production technologies, conservations, and efficiencies.

Sri Lanka

Some of the important landmarks in environmental protection include

- the enactment of the National Environment Act – 1980. This provided for the establishment of the Central Environment Authority and the Environmental Council in 1982 and a Ministry of cabinet rank on environment and related matters.
- A National Environment Action Plan was developed in 1991.
- A National Policy on Air Quality with two major components have been identified. These are for management, and are called the Clean Air 2000 with the an Action Plan called the CA2AP.

The Action Plan for air quality management in the Urban Colombo Metropolitan Area, CA2AP has been approved by the Cabinet of Ministers in 1993 and an implementation committee has been appointed.

The objectives of CA2AP are to maintain good air quality to reduce morbidity due to air pollution and in turn reduce national health expenditure and to increase the national income from industries and tourism

The National policy on air pollution abatement have been identified. These include

- Vehicle inspection and maintenance
- Fuel reformulation
- Pricing and fleet mix
- Emission inventory
- Monitoring and reduction
- Standard setting
- Institutional framework and regulatory compliance
- Transport planning and traffic management
- public awareness

Of these, vehicle inspection and maintenance has commenced on a pilot basis. Under fuel re-formulation leaded petrol should have been faced out on 1 July 2002, and the sulphur content in diesel reduced to 0. from 0.5.

Emission inventories have been developed by the electricity board and the Ceylon Petroleum corporation for the fossil fuels. Standards have been developed and gazetted for common air pollutants and for vehicular emissions.

Article 27 of the Constitution of the Democratic Socialist Republic of Sri Lanka of 1978 assigns the government the broad responsibility to Protect, Preserve and Improve the environment for the benefit of the community. Much work still remains to be done and in the interval the air pollution continues with risks to the environment, ecosystems ands individuals.

One does not doubt nor argue of the need for economic development. The question is, "Are environmental concerns being sufficiently addressed in the quest for development?'. This is the principle underlying current concept of sustainable development. Development, which addresses the concerns of environment, is the

Figure 2: Southern hemisphere with literal, 'hole' in the ozone layer

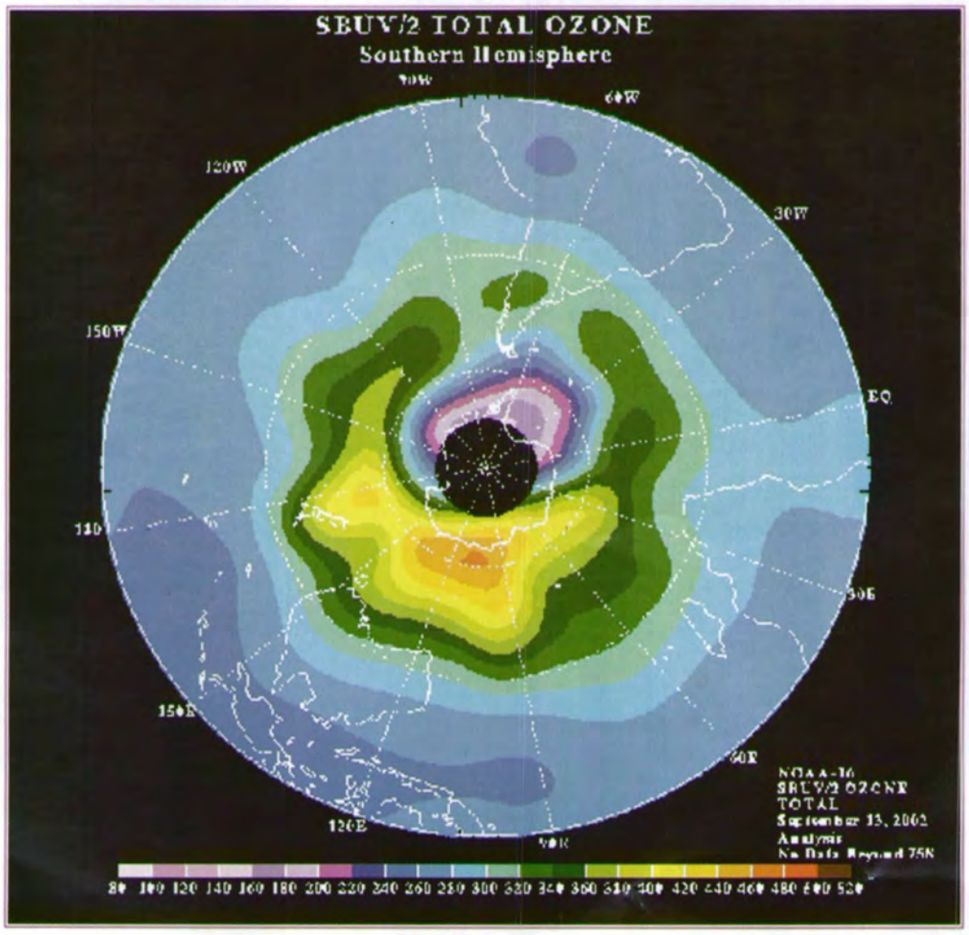
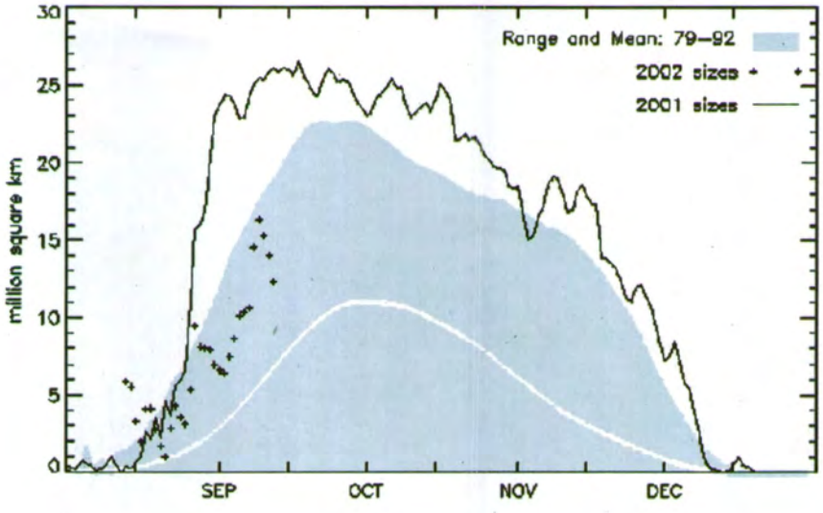


Figure 3: Daily Estimates of Ozone Hole Area



goal of many of developing countries are striving to achieve.

In conclusion, I conclude with a few thoughts for the environment

"We are only Trustees of the environment. We have no free-hold right over the environment. Just as our ancestors protected and bequeathed it to us, we must also protect and bequeath it in perfect condition to posterity".