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Management of Greenhouse Gases for Environmental Prosperity: Literature Review and Introduction to IPCC

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Abstract

The topic of interest focus on understanding of components and source for Greenhouse Gas (GHG). It also says about the anthropogenic activities and natural process responsible for GHG generation. Emission inventories of natural and anthropogenic emissions are used by scientists as inputs to air quality models, by policy makers to develop strategies and policies or track progress of standards, and by facilities and regulatory agencies to establish compliance records with allowable emission rates. E-commerce, computer climate models and counter effect properties of sulfur dioxide has also changed the view about management of GHG. The discovery of new potent GHG, trifluoromethyl sulfur pentafluoride (SF_5CF_3) is considered the most potent GHG measured till date. The objectives, responsibilities and organizational behavior of intergovernmental Panel on Climate Change (IPCC) is of importance to the people involved in the GHG management and reporting of GHG emission inventories.

Key Words* : *Greenhouse Gases, Emission inventories, Global Warming Potential sink carbon storage, Ozone depleting substance, Sulfur dioxide, Criteria pollutants, Trifluoromethy sulphur pentafluoride, e-commerce, Computer climate model ,Intergovernmental Panel on Climate Change.

Objective

This paper is the result of the effort from literature survey from various sources. The work was done in order to provide information to managers involved in greenhouse management. It provides a stepping stone for the new comers in the field of greenhouse gas studies and its management and to people who are concerned with Clean Development Policy. It also furnishes a basic information about the IPCC and its objectives. The paper also introduces some interesting topics of importance such as E-Commerce and greenhouse gases, Computer climate model and its credibility and soures, Potent new greenhouse gas(SF_5CF_3) and Counter effect properties of sulfur dioxide.

1.1 Introduction

J. Fourier first coined the term 'Green House Effect' in 1827. It is also called as 'Atmospheric Effect', Global Warming or 'Carbon dioxide problem. Several years ago, an atmospheric physics scientist, Dr. Gilbert Plass, warned that increase in CO_2 in atmosphere would have major impact in our climate (Sharma and Kaur, 1995). Later with industrialization, urbanization and with progressive development more gases accompanied CO_2. Some greenhouse gases occur naturally in the atmosphere, while others result from human activities. Naturally occuring greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide and ozone. Very powerful greenhouse gases that are not naturally occurring include hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6), which are generated in a variety of industrial processes.

Those, which cause adverse effects, are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluoro carbons (CFCs). All these gas came to be called as 'Greenhouse Gas (GHG). The Green house effect may be defined as 'The progressive warming up of the earth's surface due to blanketing effect of anthropogenic gases in the atmosphere.

Each greenhouse gas differs in its ability to absorb heat in the atmosphere. HFCs and PFCs are the most heat-absorbent. Methane traps over 21 times more heat per molecule than carbon dioxide and nitrous oxide absorbs 270 times more heat per molecule than carbon dioxide.Often estimatesof greenhouse gas emissions are presented in units of millions of metric tons of carbon equivalents (MMTCE),which weights each gas by its GWP value or Global Warming Potential. Green House Effect (GHE) is essential for mankind and life. But man's activities are accelerating or enhancing the warming process to cause concern. All the green house gases are increasing at rapid rate. Increase in mean temperature created by green house effect would greatly affect man and other flora and fauna (Saji and Chacko 2001). Among the various emerging environmental issues UNEP(United Nations Environment Program) has identified global warming effect called, "green house effect" as most vexatious displeasing and disquieting. The control of greenhouse gas emission continues to be a major global problem.It is inter-disciplinary, both substance and approach and covers technical, political and economic issues involving governments, industry and the scientific community. The 1990s decade was the hottest decade of the last century and the warming is warmer than anything in the last 1,000 years.

The earth's atmosphere is warming faster than expected and evidence is mounting that human activity is responsible, the United Nations Environment Program has said. The UN's Intergovernmental Panel on Climate Change (IPCC) now projects the earth's average surface temperature will rise1.4 to 5.8 degree Celsius between 1990 and 2100 higher than its 1995 estimate of a one to 3.5

degree rise. There's no doubt the earth's climate is changing," IPCC chairman Robert Watson told a news conference in Shanghai on January 22, 2001.

Greenhouse Gas management for sustainable development is an overaching objective for human society that has emerged at the end of the twentieth century. The interaction between sustainable development and global climate change is especially important in view of the wide-ranging impact that the latter is likely to have (Catrinus and Munasinghe, 1998).

History of Green House Effect

CO_2 concentration was about 200 ppm only 20,000 years ago and corresponding temperature was 4^0 to 5^0 C lower than now. The value was 280 ppm about 10,000 years ago, 290 in 18 60, about 320 ppm in 1970 ,340-360 ppm in 1988 and is expected to be doubled by 2030 AD. The role of CO_2 can be visualized by comparing Earth with Mars and Venus. Venus has a large CO_2 content while Mars has very little. The net result is Venus is hot at 477^0 C, Mars is cold at-47^0C and the Earth has an average temperature of about 16^0C (Murali and Venkatarao, 1998).

1.2 Greenhouse Gas Impact on Environment

The decade of the 1990s was the hottest decade of the last century and the warming in this century is warmer than anything in the last 1,000 years in the Northern Hemisphere, IPCC chairman Roert Watson told a news conference in Shanghai on January 22, 2001. "We see changes in climate, we believe we humans are involved and we're projecting future climate changes much more significant over the next 100 years than last 100 years " he added.

Watson said the IPCC's latest report on climate change showed the main reason behind the faster than expected temperature rise was a fall in sulphur dioxide emissions. Green house gases such as carbon dioxide tend to warm the earth's atmosphere whereas sulphur dioxide tends to cool it. More disease, less water. Watson said the implications of global warming on human health include increases in heat stress mortality in the summer and diseases such as malaria and dengue fever. It could also hit agriculture and water resources. Changing regional climate could alter forests, crop yields and water supplies. It could also threaten human health, and harm birds, fish, and many types of ecosystems. Deserts may expand into existing rangelands and the character of some of our National Parks may be permanently altered. Unfortunately many of the potentially most important impacts depend upon whether rainfall increases or decreases, which can not be reliably projected for specific areas.

Fluctuation in global temperature with increasing level of GHS is not expected to be uniform entire globe. Recently in "World Climate Program "(WCP), it is estimated nearly 3 degree Celsius rise in temperature for doubling of atmoshpheric CO_2 and the probability of slight temperature change in the tropics, a 2 to 3 degree Celsius increase at mid latitudes and 8 to 10^0C in the polar regions. Actually air pollutants such as CH_4, N_2O, O_3, CFCs, CCl_3F posses intense infrared absorption, which could influence mean global temperature. The most adequate explanation is that the increase in CO_2 and aerosol content of the air has the potential to fluctuate the world's climate. According to UNEP, within next 25 years or so, there will be a rise in sea level by 1.5 to 3.5 meters (Sharma and Kaur 1995 and Bowen 1979).

1.3 Emission Inventories- Gases, Source and Sink

1.3.1 What are Emission Inventories?

An emission inventory is an accounting of the amount of air pollutants discharged into the atmoshpere. It is generally characterized by the following factors:

-the chemical or physical identity of the pollutants included,

-the geographic area covered,

-the institutional entites covered,

-the time period over which emissions are estimated, and

-the types of activities that cause emissions.

Emission inventories are developed for a variety of purposes. Inventories of natural and anthropogenic emissions are used by scientists as inputs to air quality models, by policy makers to develop strategies and policies or track progress of standards, and by facilities and regulatory agencies to establish compliance records with allowable emission rates. A wall-constructed inventory should include enough documentation and other data to allow readers to understand the underlying assumptions and to reconstruct the calculations for each of the estimates included.

The emission catergories prescribed by the IPCC 95 Guidelines for national greenhouse gas inventories have been considered.

1.3.2 Greenhouses Gases Categorization

A) Direct Greenhouse Gases: Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC) and perfluorocarbons (FC such as CF_4 and C_2F_6).

B) Indirect Greenhouse Gases: Nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), carbon monooxide (CO), ozone (O_3), sulphur oxide (SO_x) and sulphur hexafluoride (SF_6).

1.3.3 Source of Greenhouse Gas Emissions

1.3.3 .1 Greenhouse Gas Emission (Based on Components)

1.3.3.1 a Carbon Dioxide Emission

Emission of carbon dioxide from coal and other combustion constitute a very significant contribution to total emission of GHGs from anthropogenic sources. In general, emissions of CO_2 are evaluated as the product of the quality of fuel sort and the corresponding emission factor for carbon dioxide (Pavel 1999). According to the standard IPCC methodology for GHG inventories (IPCC, 1997), Cabon Emission Factors (CEFs) are referred to the energy unit of each sort of fuel. The global carbon cycle is made up of large carbon flows and reservoirs. Hundreds of billions of tons of carbon in the form of CO_2 are absorbed by oceans and living biomass (sinks) and are emitted. See section 1.3.4 for more details.

1.3.3.1 b Methane Emissions

Atmospheric methane (CH_4) is an integral component of the greenhouse effect, second only to CO_2 as a contributor to anthropogenic GHS emissions. Methane's overall contribution to global warming is significant because it is estimated to be 21 times more effective at trapping heat in the atmosphere than CO_2 i.e., the GWP (Global Warming Potential) value of methane is 21. Over the last two centuries, methane's concentration in the atmosphere has more than doubled (IPCC 1996). Experts believe these atmospheric increases were due to largely increasing emissions from anthropogenic sources, such as landfills, natural gas and petroleum systems, agricultural activities, coal mining, stationary and mobile combustion, wastewater treatment and certain industrial processes atmoshpere annually through natural processes or sources. When in equilibrium carbon fluxes, among these various reservoirs are roughly balanced. Since the Industrial Revolution, the equilibrium of atmospheric carbon and methane has been altered (Cicerono and Oremland 1988, Sebacher *et al.* 1985, Sebacher *et al.* 1986).

Landfills

Landfills are the largest single anthropogenic source of methane emission. In an environment where the oxygen contents is low or nonexistent, organic materials, such as yard waste, household waste, food waste, and paper can be decomposed by bacteria, resulting in the generation of methane and biogenic CO_2. Methane emissions from landfillss are affected by site-specific factors such as waste composition, moisture and landfill size.

Natural Gas and Petroleum Systems

Methane is the major component of natural gas. During the production, processing, transmission and distribution of natural gas, fugitive emissions of methane often occur. Because natural gas is often found in conjunction with petroleum deposits, leakage from petroleum system is also a source of emission. Emissions vary greatly from facility to facility and are largely a function of operation and maintenance procedures and equipment condition.

Petroleum is found in the same geological structures as natural gas, and the two are retrieved together. Methane is also saturated in crude oil, and volatilizes as the oil is exposed to the atmosphere at various point along the system. Methane emissions from the components of petroleum systems including crude oil production, crude oil refining and transportation.

Coal Mining

Produced millions of years ago during the formation of coal, methane trapped within coal seams and surrounding rock strata is released when the coal is mined. The quantity of methane released to the atmosphere during coal mining operations depends primarily upon the depth and type of the coal that is mined.

Methane from surface mines is emitted directly to the atmosphere as the rock strata overlying the coal seam are removed.Because methane in underground mines is explosive at concentrations of 5 to 15 percent in air, most active underground mines are required to vent this methane, typically to the atmosphere. At some mines ,methane-recovery system.

Other Sources

Methane is also produced from several other sources, including fuel combustion, wastewater treatmen, and some Industrial processes may supplement these ventilation systems and distribution generally occur as a result of system leaks, disruptions, and routine maintenance.

1.3.3.1c Nitrous Oxide Emissions

Nitrous oxide (N_2O) is a greenhouse gas that is produced both naturally, from a wide variety of biological sources in soil and water and anthropogenically by a variety of agricultural, energy related, industrial, and waste management activities (Anderson *et al.* 1986). While N_2O emissions are much lower than CO_2 emissions, N_2O is approximately 310 times more powerful than CO_2 at trapping heat in the atmosphere (IPCC 1996). During the past two centuries, atmospheric concentrations of N_2O have risen by approximately 13 percent.

As the emission inventories indicated (Second Report of the Govt. of Federal Republic of Germany on Environmental Policy of Climate Protection in Germany), there are three main sources of N_2O emissions.

* Industrial processes (adipic and nitric production).
* agriculture (animal husbandry, fertilizer use).
* combustion of fossil fuels.

Agricultural Soil Management

Nitrous oxide (N_2O) is produced naturally in soil through microbial processes of nitrification and denitrification. A number of anthropogenic activities add to the amount of nitrogen available to be emitted as N_2O by these microbial processes. Direct additions of nitrogen occur through the application of synthetic and organic fertilizers, cultivation of nitrogen-fixing crops, cultivation of high-organic-content soils,the application of livestock croplands and pasture, the incorporation of crop residues in soils, and direct excretion by animals onto soil. Indirect emissions result volatilization and subsequent atmospheric deposition of ammonia (NH_3) and oxides of nirogen (NO_x) and from leaching & surface run-off, Their indirect emissions originate from nitrogen applied to soils as fertilizer and from managed and unmanaged livestock waste. The biogenic soil emission of nitrous oxide is also prominent (Levin, 1989 and Levin, 1991).

Fuel Combustion

Nitrous oxide is a product of the reaction that occurs between nitrogen and oxygen during fuel combustion. Both mobile and stationary combustion emit N_2O and the volume emitted varies according to the type of fuel, technology, and pollution control device used, as well as maintenance and operating practices. For example catalytic converters installed to reduce highway vehicle pollution can result in the formation of N_2O.

Adipic Acid Production

The majority of the adipic acid produced in the United States is used to manufacture nylon6,6 Adipic acid is also used to produce some low temperature lubricants , and to add a "tangy" flavor to foods. Nitrous oxide is emitted as a by-product of the chemicalsynthesis of adipic acid.

Nitric acid Production

Nitric acid production is another industrial source of N_2O emissions. Used primarily to make synthetic commercial fertilizer, this raw material is also a major component in the production of adipic acid and explosives. Virtually all off the nitric acid manufactured in the United States is produced by the oxidation of ammonia, during which N_2O is formed and emitted to the atmosphere.

Manure management

Nitrous oxide is produced as part of microbial nitrification and denitrification processes in managed and unmanaged manure, the latter of which is addressed under agricultural soil management.

Other Source

Other sources of N_2O included agricultural residue burning, waste combustion and human sewage in wastewater treatment systems.

1.3.3.1b HFCs, PFCs & SF_6 Emissions

Substitution of Ozone Depleting Substances

Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are categories of synthetic chemicals that are being used as alternatives to the ozone depleting substances (ODSs). Because HFCs and PFCs do not directly deplete the stratospheric ozone layer, they are not controlled by the Montreal Protocol.

These compounds, however ,along with sulfur hexafluoride (SF_6),are potent greenhouse gases. In addition to having high global warming potentials ,SF_6 and many HFCs and PFCs have extremely long atmospher lifetimes, resulting in thier essentially irreversible accumulation in the atmosphere. Sulfur hexafluoride, itself, is the most potent greenhouse gas the IPCC has evaluated. The use and subsequent emissions of HFCs and PFCs as ODS substitutes increased in recent years. This increase was the result of efforts to phase-out CFCs and other ODSs especially the introduction of HFC-134a as a CFC substitute in refrigeration applications. This trend is expected to continue for many years, and will accelerate in the early part of the next century as HCFCs (Hydro chloro fluoro carbons) which are interim substitutes in many applications, are themselves phased-out under the provisions of the Copenhagen Amendments to the Montreal Protocol.

Other Industrial Sources

In addition to their use as substitutes for ozone depleting substances, the other emissive sources of these gases are aluminum production, HCFC-22 production, semiconductor manufacturing, electrical transmission and distribution, and magnesium production and processing. During the production of the primary aluminum, two PFCs (CF_4 and C_2F_6) are emitted as intermittent by-products of the smelting process. HFCs, PFCs, and SF_6 are also emitted from a number of other industrial processes.

1.3.3.1e Criteria Pollutant Emissions

In the United States carbon monoxide (CO), nitrogen oxides (NOx), nomethane volatile organic compounds (NMVOCs),and sulfur dioxide (SO_2) are commonly referred to as "criteria pollutants", as termed in the Clean Air Act. Criteria pollutants do not have a direct global warming effect,but indirectly affect terrestrial radiation absorption by influencing the formation and destruction of tropospheric and stratospheric ozone, or, in the case of SO_2, by affecting the absorptive characteristic of the atmosphere. Carbon monoxide is produced when carbon-containing fuels are combusted incompletely. Nitrogen oxides (i.e. NO and NO_2) are created by lightining, fires, fossil fuel combustion and in the stratosphere from nitrous oxide (N_2O). NMVOCs which include such compounds as propane, butane and ethane are emitted primarily from transporta-

tion, industrial processes and non-industrial consumption of organic solvents. In the United States, SO_2 is primarily emitted from the combustion of fossil fuels and by the metals industry.
In part because of their contribution to the formation of urban smog and acid rain in the case of SO_2 and NO_x. These gases also indirectly affect the global climate by reacting with other chemical compounds in the atmosphere to form compounds that are greenhouse gases. Unlike other criteria pollutants, SO_2 emitted into the atmosphere is believed to affect the earth's radiative budget negatively; therefore, it is discussed separately in section 1.9.
One of the most important indirect climate effects of criteria pollutants is their role as precursors for troposphere ozone formation. They can also alter the atmospheric lifetimes of other greenhouse gases. For example, CO interacts with the hydroxyl radical the major atmospheric sink for methane emission to from CO_2. Therefore, increased atmospheric concentrations of CO limit the number of hydroxyl molecules (OH) available to destory methane (Bowen, 1979).
Fuel combustion accounts for the majority of emissions of these gases (Crutzen and Andreae, 1990; Lobert *et al.* 1991). Industrial processes such as the manufacture of chemical and allied products metals processing and industrial uses of solvents are also significant sources of CO, NO_x, and NMVOs.

1.3.3.2 Greenhouse Gas Emission (Based on Anthropogenic Activities)

Sources of greenhouse gases are grouped under the following categories:

1.3.3.2a Energy-Related Emissions

1) Combustion Related

i) Energy and transportation industries
ii) Industry
iii) Transport (Road, Sea and Air)
iv) Residential, Commercial and Institutional (Not including transports in agriculture, silviculture and fisheries)
v) Other (military and including transports in agriculture, silviculture and fisheries)
vi) Combustion of Biomass

2) Production, Processing and Distribution of fuels

i) Solid Fuels
ii) Oil and Gas

3) Geothermal Energy

i) Geothermal Energy Production

1.3.3.2b Industrial Processes

i) Iron and Steel

ii) Non-Ferrous Metals

iii) Inorganic Chemicals

iv) Organic Chemicals

v) Non-Metallic Mineral Products

iv) Other

1.3.3.2c Solvent and Other Product Use

i) Paint

ii) Degreasing and Dry Cleaning

iii) Chemical Product Manufacturing/Processing

iv) Other

1.3.3.2d Agriculture

i) Fermentation

ii) Animal Waste

iii) Agriculture Soils

iv) Combustion of Agricultural Waste

v) Use of Chemicals in Agriculture

1.3.3.2e Land-use Changes and Forestry

i) Changes in Forests

ii) Conversion of Forest and Grassland

iii) Set-aside of Agricultural Land

iv) Abandonment of Managed Lands

v) Other

1.3.32f Waste Management

i) Landfills

ii) Waste Treatment

iii) Waste Incineration

Geothermal energy production increases the emission of geothermal steam and of the gases present there in. Emission from feed stocks is in the industrial process category of the inventory. For the production of iron and steel (ferrosilicon) the usage of carbon electrodes and coal have been considered feed stocks and accordingly included under the industrial processes category. For the production of aluminium the feed stocks are alumina, cryolite and carbon electrode which emissions handed similarly. The inventory includes for emissions of carbon dioxide, fluorocarbons and sulphur oxides. For non-metal mineral production the main feed stocks causing emissions is the use of calcium carbonate from mollusc shell sand, in cement production.

1.3.4 Sink and Carbon Storage

What Are Sinks?

A sink is a reservoir that uptakes a chemical element or compound from another part of its cycle. For example, soil and trees tend to act as natural sinks for carbon-each year hundreds of billions of tons of carbon in the form of CO_2 are absorbed by oceans, soils, and trees. The major natural sinks are oceans and vegetation, they are also the sources. Carbon dioxide is absorbed and stored in vegetation as Organic Compounds.

Sequestration of CO_2

Storage of CO_2 in geological formations is attracting considerable attention nowadays. In order to find out more about the practical constraints on underground storage, the first of a series of studies on barriers to implementation of CO_2 capture and storage has examined storage in disused oil and gas fields. This study also provides up-dated estimates of the global storage capacity of depleted oil and gas fields including the potential for use of CO_2 for enhanced oil recovery. One of the options considered recently has been the conversion of CO_2 into a mineral carbonate,which offers the potential for very secure storage; this was reported in CO_2 storage as carbonate minerals. Various ideas have been proposed for storage as hydrates.

Another possible place for storing CO_2 would be in the deep ocean but this would be likely to raise many questions. The ocean is a natural sink for $CO_{2,}$ taking up more than it releases to the atmosphere. Increasing the rate at which the ocean takes up CO_2 from the atmosphere, by artificial fertilization, could be used to increases the net take-up (i.e. the amount stored).Having reviewed this option previously, one of the outstanding questions about macronutrient fertilization has now been examined through a modeling study-Enhancement of oceanic uptake of CO_2 by macronutrient fertilization.

Increasing the terrestrial sink is an analogous option on land. This could be done, for example ,by increased afforestation. Even though urban forestry and greenbelt have common objective of reducing atmospheric air pollutant load among them some are GHG, but their definition and mode of achieving this objective are widely different. A fast growing tree absorbs upto 22 kilograms of Carbon-dioxide per year, that is about 10 tons per acre of tree enough to offset the Carbon dioxide produced by driving a car 34,000 km. (Saji, 1998).

The role of vegetation in mitigating the excess of Carbon dioxide and the warmth of the atmosphere has been appreciated since long as they can store large amounts of carbon. Vegetation may be able to moderate or postpone built up of atmospheric carbon and thereby delay the process of global warming. The expert on the science of global warming thinks that it is possible to expand the existing carbon sink or create new ones. Such carbon sink could sequester the excess 2.9 billion tons of free carbon dioxide (Shukla, 1983).

John Martin of United States has floated suggestion that a few hundred thousand tons of iron (Fe) be dumped into the ocean around Antarctica, which would rise the species of phytoplankton in water. They grow like crazy and draw CO_2 out of the atmosphere, thus cooling down an over heating planet. Martin's idea has raised quite a few eyebrows, but with raising temperature one can hardly effort to take any chances. Martin measured the concentration of several trace metals in seawater, among them Fe too. He observed that the poor growth of phytoplankton on the water aound Antarctica is due to an acute deficiency of Fe.

1.4. Potent New Greenhouse Gas

A report from MAINZ, Germany, July 31, 2000 (ENS)- Researchers from seven institutions in Germany, the United Kingdom and the United States have detected a previously unreported compound of industrial origin in the atmosphere- trifluoromethyl sulfur pentafluoride (SF_5CF_3). It is considered the most potent Greenhouse Gas measured to date.

The new greenhouse gas was discovered by scientists at the Max Planck Institute for Chemistry in Mainz, Germany, working with researchers from the School of Environmental Science at University of East Anglia in the UK, Ford Motor Company, USA, University of Reading,UK; Natural Environment Research Council in Cambridge, UK; and the University of Frankfurt working with scientists from the British Antarctic Survey.

There is no doubt that the new gas SF_5CF_3 is made by industry or is produced during certain processes involving industrial gases, but its exact source remains a mystery. Analysis of Antarctic snow revealed a new greenhouse gas, SF_5CF_3. The increase of this peculiar gas in the atmosphere is coupled with the increase of the very inert gas sulfur hexafluoride (SF_6), suggesting a common source, according to their article in the journal "Science", a publication of the American Association for the Advancement of Science. Emissions of sulfur hexafluoride (SF_6) are governed by the Kyoto Protocol,an addittion to the United Nations Climate change treaty. It is one of the six greenhouse gases linked to global warming.

The scientists speculate that SF_5CF_3, which is closely chemically related to SF_6 ,originates as a breakdown product of SF_6 in high voltage equipment. SF_6 is used in electrical switches to suppress sparks, in protecting metals during a melting process, in tennis balls, car tires and even at one stage in running shoes. Due to its good insulation properties it was also used as a noise barrier in double glazed windowpanes.

SF_5CF_3 is a breakdown product of the gas SF_6 in high voltage equipment. SF_6 is used to electrically insulate high voltage components. SF_6 is a strong greenhouse gas and the molecule is very resistant against attack in the atmosphere. The natural self-cleansing property of the atmosphere is insufficient to deal with such super molecules. It has a long lifetime, and being a strong greenhouse gas, its production is now restricted under the Kyoto Protocol.

The new molecule SF_5CF_3 is even a stronger greenhouse gas. Measurements of its infrared absorption cross section revealed the largest radiative forcing, on a per molecule basis, of any gas found in the atmosphere to date, the discoverers report. It has a long lifetime- somewhere between several hundred and a few thousand years.

The researchers found this new gas while conducting expeditions in Antarctica to extract air samples from the thick firm layers of snow. These layers up to 100 meters thick, contain old air, sometimes from the beginning of the last century, according to Carl Brennikmeijer of the Max Planck Institute.

" This air has been extensively analyzed in our institute and in Norwich, England. The new gas was discovered at extremely low concentrations" he said. "Without even knowing it, we have been releasing a very potent greenhouse gas for almost 50 years. We have to find the source of this gas and to try to stop its increase," Brenninkmeijer said.

1.5 Greenhouse Gas Emission-Trends in Energy Production and Consumption

Current pattern in production, development and consumption around the globe pose serious threat to global ecosystem. In all the process energy is consumed, produced and transformed in any form. Carbon fuel is the major source of energy. In the transaction, liberation of pollutants is a common phenomenon. GHG is a part of it. Economy of nation is the measure of the energy status. The pattern of utlilization and involvement of energy in development judges its contribution towards GHG account.

Curbing the GHG depends upon the correlation between economy, energy and technical advancement. But some where the policies, management or system process has to compromise with the factors or component in the technical development system as whole for sustained GHG control and checking. Reviews by Capoor *et al.* (1996) and Reid and Goldemberg (1997) have cited significant steps that are being taken by developing countries to reduce rates of growth in carbon emissions.It is seen that since the United Nations Framework conventions on Climate Change (UNFCCC) ,carbon emission savings in development countries are very much prominent than industrialized countries (Reid and Goldemberg, 1997).

Energy use for various services has a number of impacts on the environment. Energy combustion by-products include SO_x, NO_x and precursors of ground-level ozone. Another combustion by-product is CO (carbon dioxide). CO_2 a greenhouse gas, has been identified as a potential major contributor to global climate change (Hao *et al.* 1990).

Clean energy technologies may be one of the most effective responses to reducing greenhouse gas emissions.

1.5.1 The Carbon Emissions from Energy Use Depend on a Number of Factors

The level of demand for energy services,

The service energy intensity (energy requirement per unit of service).

The mix of energy sources for the service,

The carbon content of the energy sources,

Electricity and other energy is derived from other forms of energy. For these sources, the mix of fuels may be used in their production, which is an additional factor in carbon emissions. Energy efficiency affects the service energy intensity. If energy were used more efficiently, the energy intensity would decrease, as would the carbon emissions, while maintaining the same level of service.

1.5.2 General Trends in Carbon Emission in Industries (Data related to US)

The statistical data varies from underdeveloped to developed through developing nations based on infrastructure, technologies, available resources and process.

(i)Carbon Emission in Manufacturing Industries

Manufacturing, which accounts for about 80 percent of industrial energy consumption, also accounts for about 80 percent of industrial energy-related carbon emissions. (Agriculture, mining forestry, and fisheries account for the remaining 20 percent). Three industries, petroleum chemicals, and the primary metals emitted almost 60 percent of the energy-related carbon in manufacturing. The next three largest emitters (paper, food, and the stone, glass and clay products industry) produced an additional 22 percent of the energy-related manufacturing emissions.

The carbon intensity of energy use is the amount of carbon emitted per unit of energy used. Both the mix of energy sources used and uses of energy affect carbon intensity. For electricity that manufacturers purchase, the carbon emissions occur where the electricity is generated, rather than at the manufatcturing establishment. These emissions are assigned here to the ultimate user. The metals industry has a relativey high carbon intensity, due to the extensive use of coal (primarily in the iron and steel industry) and electricity (in the aluminium and iron and steel industries). In contrast, the paper industry has relatively low carbon intensity, due to its use of renewable energy sources. The two industries with the highest carbon emissions, the petroleum refining and chemicals industries, have relatively low carbon intensities. These industries use large amounts of energy, but do not use all of that energy as fuel.Instead, these industries convert energy sources, such as liquefied petroleum gases or natural gas, into other products. A portion of the carbon contained in the original energy source is sequestered in the product rather than emitted to the atmosphere.

(ii) Carbon Emissions in the Coal and Petroleum refining Industry

Petroleum refining is by far the largest component of the petroleum and coal products industry. The petroleum refining industry uses almost 30 percent of all energy used in manufacturing and emits over 20 percent of the carbon. Only about half of the energy is used as fuel; the rest is used as feedstock. Over half of petroleum refining carbon emissions is from petroleum by products (chiefly still gas and petroleum coke) used as fuel. A significant amount of carbon is sequesterd in petrochemical feedstock, resulting in a relatively low overall carbon intensity.

(iii) Carbon Emissions in the Chemical industry

The chemical industries as a whole uses almost 25 percent of manufacturing energy and emits over 20 percent of the carbon. The plastics industry alone emits over 2 percent of all natural gas and electricity are two largest sources of energy-related carbon emissions for the chemical industry. A significant amount of the carban content of the energy is sequestered in chemical industry products, such as plastics and fertilizers, rather than emitted through combustion.

(iv) Carbon Emissions in the Iron and Steel Industry

Besides steel mills and blast furnaces, the primary metals industry also includes the aluminium industry, copper industry, and other metal industries, Within this group the iron and steel industry emits our 60 percent of the energy related carbon.

Coal accounts for almost 60 percent of the energy-related carbon emissions in the iron and steel industry. Electricity and natural gas use, emits an additional 35 percent of the energy-related carbon. Almost all of the coal is converted to coke for the manufacture of steel, rather than used directly as a source of fuel.

(v) Carbon Emissions in the Paper Industry

Paper and paperboard mills emit over 80 percent of the energy-related carbon in the paper industry. Electricity, natural gas and coal account for most of the energy-related carbon emissions in the paper industry. Nearly half of the energy used in the paper industry is renewable, consisting of wood and paper byproducts (pulping liquor, wood chips, and bark). Renewable energy sources are not considered net emitters of carbon.

(iv) Carbon Emissions in the Food Industry

The food industry group encompasses a wide variety of industries. The wet corn milling industry emits almost a sixth of the energy-related carbon in the food industry. Two sources, natural gas and electricity , each account for roughly 40 percent of the energy-related carbon emissions in the food industry. About one-sixth of the emissions come from the use of coal.

(vii) Carbon Emissions in the Stone, Clay and Glass Industry

The cement and lime manufacturing industries emit almost half of the energy-related carbon in the stone, clay, and glass group of industries. The cement and lime industries also emit a significant amount non-energy-related carbon. Three sources coal, natural gas, and electricity account for 91 percent of the energy-related carbon emissions in the stone, clay, and glass industries.

1.6 E- Commerce and greenhouse gas

E-Commerce will have far-reaching social and environmental impacts, from changes in the use of raw material and energy to new settlement and transportation patterns that affect our communities (Saji and Chacko, 2001).

Sustainable development has increasingly become a critical issue facing both developing and developed countries. In addition to global warming and environment deterioration, the emerging information-based economy has raised attention of policy-makers in almost all countries. No country can afford to lose this new round of competition. There are many factors that are critical, to the success of the new economy. To guarantee the sustainable development of the information infrastructure and henceforth the sustainable development of the society and economy, appropriate policy and strategy are therefore extremely critical.

"It's unlikely e-commerce will save the planet as some have claimed", says Bette Fishbein, a senior fellow at Inform, an environmental research organization in New York City. "There might be some reductions in energy use, but there's a huge increase in packaging and shipping by air results in much more air pollution. Office paper use has doubled since the wide-spread use of computers so much for promise of the paperless office." But on other hand "Joseph Romm, executive director of the Center for Energy and Climate Solutions and an expert in energy use" says. "The economy is growing rapidly, but energy demand is much lower since the advent of the Internet and thus reducing the greenhouse emission."

There is a debate over electricity and the Internet. We're using a fair amount of electricity to keep the Internet economy hot. Internet use could eventually have an important impact on energy consumption and greenhouse gas emissions. The Internet also generates energy gains through ematerializations. E-materialization of paper, construction, and other activities could produce greenhouse gas savings. The statistics from some publication reports-greenhouse gas savings for avoiding the use of a ton of paper is estimated at 3.3 metric tons of carbon dioxide equivalent of newspapers and 3.8 for office paper. Despite increased use of office paper, use of the Internet could save 2.7 million tons of paper annually by 2003. The resulting cut in global warming pollution will equal some 10 million tons of carbon dioxide. Both figures could double by 2008.

A minute spent driving to a store uses more than 10 times the energy of a minute spent shopping on-line. On-line shopping avoids car trips and reduces congestion, and mobile emissions (Saji and Chacko 2001). Nearly 40 percent of people with Internet access say they go to stores less often. It seems clear that the "new energy economy" will profound impacts on energy, environment and economic forecasting. The e-commerce impact on energy use, however, should not be viewed as a panacea.

Confusion still persists in the contribution of e-commerce towards green environment and the debate is still continuing. Whole computer industries right from the use and process of raw materials for the production of computers, its accessories, operation and application results need to be accessed with reliable attitude. Is e-commerce a friend or foe of the environment?

1.7 Greenhouse Gas Dynamics (GGD) Studies

Greenhouse Gas Dynamics (GGD) includes research and studies on the complex chemical processes both natural and industrial, which lead to GHG production and release and on the interactions of greenhouse gases with light, other atmoshperic gases, surfaces, and other relevant substances. Research focused on laboratory investigation of processes at the molecular level, development of experimental data necessary for effective modeling and prediction of greenhouse gas effects on a global scale, and identification of alternative, less environmentally destructive substances.

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Photochemical studies of greenhouse gases, undertaken because of environmental relevance, have revealed much about the reaction chemistry of isolated gases. The complex nonlinear interactions of multiple gases and phases, however are only vaguely understood despite their clear climatic importance. Photochemical studies aimed at improving understanding of the behavior of complex systems are encouraged.

Only recently has it been appreciated that a combination of mass and thermal transport, photochemistry and surface chemistry is necessary to desribe interactions of GHGs in the atmosphere. This progress supports investigations of adsorption, photochemistry and bulk reactions between GHGs and other substances frequently at surfaces or in aerosols or hydrosols which deterrmine their environmental impact on global climate change. Surface interaction studies that point to new and effective means for selectively removing GHGs from process streams or catalyzing their conversion to innocuous substances are also appropriate.

Proposals for development of new physical and chemical tools to carry out analysis essential for characterization of environmentally critical interactions to be considered (National Academic of Sciences, 1984). Attention will be given to developing reliable techniques for in situ sensing and quantification of GHGs and understanding fundamental chemistries underlying passive and active sensor design.

1.8 Computer Climate Model and Its Credibility

Even when measured against the suspect data gathered from surface thermometers in towns and cities, the warming is still well below that which models say should have happened by now. When compared with the more accurate and global satellite temperature series since 1979, the gap between theory and reality is even wider.

According to Tom Wigley, chief scientist of the National Center for Atmospheric Research, Boulder, Colorado, USA why global warming has fallen so far short of what computer models say should be happening by now?

Reasons or Excuse

In a paper published, not in a scientific journal, but by the rich environmentalist Pew Center on Global Climate Change', titled "The Science of Climate Change: Global and U.S. Perspectives," Tom Wigley repeats, by now, lame excuse to explain away the lack of warming so far.

The critical issue is Sulfur Dioxide (SO_2), a common byproduct of fossil fuel burning in older combustion systems. These 'sulfates' are blamed for acid rain and newer combustion systems extract sulfates before they escape to the atmosphere. As the newer technology spreads in usage, sulfate levels in the atmosphere can be expected to fall.

Several years ago the Greenhouse Industry seized on a theory floated by prominent US greenhouse skeptic Prof. Patrick Michaels, namely that the presence of sulfates in cloud formations made them brighter to sunlight. Brighter clouds would make them more reflective, thus tending to cool the earth, partially countering the warming effect alleged from carbon dioxide (CO_2).

While Michaels originated this hypothesis, he was also very prompt in discarding the theory when it was clear that observational evidence did not support it-as any good scientist would. But good scientists do not inhabit the Greenhouse Industry. They saw in Michaels' sulfate theory the excuse they needed for the lack of significant warming to date. Rather than pay heed to the mounting physical evidence that the sulfates theory was a non-starter, they instead incorporated the theory into the climate models, making it a dogma of faith among environmentalists and even the Intergovernmental Panel on Climate Change (IPCC).

But Wigley has given the sulfates theory an added twist in his latest paper. Having claimed that sulfates have been applying a cooling brake to global warming, he then went on to claim that global warming would accelerate even faster than expected once the sulfate emissions were wound back. If we save the world from acid rain, we might exacerbate the global warming problem.

1.9 Sources and Counter Effect Properties of Sulfur Dioxide.

Sulfur dioxide (SO_2)emitted into the atmosphere through natural and anthropogenic processes affects the earth's radiative budget through its photochemical transformation into sulfate aerosols that can

(i) Scatter sunlight back to space, thereby reducing the radiation reaching the Earth's surface;

(ii) Affect cloud formation; and

(iii) Atmospheric chemical composition (e.g., Stratospheric ozone, by providing surfaces for heterogencous chemical reactions).

The overall effect of SO_2 derived aerosols on radiative forcing is believed to be negative (IPCC 1996). However, because SO_2 is short-lived and unevenly distributed in the atmosphere, its radiative forcing impacts are highly uncertain.

Sulfur dioxide is also a major contributor to the formation of urban smog, which can cause significant increases in acute and chronic respiratory diseases. Once SO_2 is emitted, it is chemically transformed in the atmosphere and returns to the Earth as the primary source of acid rain. Electric utilities are the source of SO_2 emissions. Coal conbustion contributes nearly all of those emissions. Sulfur dioxide emissions have decreased in recent years, primarily as a result of electric utilities switching from high sulfur to low sulfur coal.

1.10 The Intergovernmental Panel on Climate Change (IPCC) *What's the Intergovernmental Panel on Climate Change?*

Is the premier organization for National Greenhouse Gas (GHG) Inventories and Programs. The World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988. Its main objective was to assess scientific, technical and socio- economic information relevant to the understanding of human induced climate change, potential impacts of climate change and options for mitigation and adaptation. The IPCC brings together the world's top scientists in all relevant fields, synthesizes peer-reviewed scientific literature on global warming studies, and produces authoritative assessments of the current state of knowledge of climate change. The IPCC has completed two assessment reports, developed methodology guidelines for national greenhouse gas inventories, special reports and technical papers.

About National Greenhouse Gas Inventories Program

A national greenhouse gas inventory is a record of the emissions by sources and uptake by sinks of greenhouse gases and their precursors that arise from human activities in a country over a year. Nations have committed themselves to producing such inventories annually under the United Nations Framework Convention on Climate Change.

The IPCC has Three Working Groups and a Task Force

Working Group I (WGI): The science of climate change

Working Group II (WG II): Impacts, adaptation and vulnerability

Working Group III (WG III): Mitigation of climate change and

Task Force on National Greenhouse Gas Inventories (TFI)

The TFI was established by the IPCC, at its 14th session (October 1998), to oversee the IPCC National Greenhouse Gas Inventories program (IPCC-NGGIP). This program had been undertaken since 1991 by the IPCC WG I in close collaboration with the Organization for Economic Co-operation and Development (OECD) and the International Energy Agency (IEA). In 1999, The Technical Support Unit (TSU) set up at the Institute for Global Environmental Strategies (IGES) in Japan took over this program in accordance with a decision taken by the IPCC at its 14 th session.

The Objectives of the IPCC-NGGIP are to develop and refine an internationally-agreed methodology and software for the calculation and reporting of national GHG emissions and removals, and to encourage the widespread use of this methodology by countries participating in the IPCC and by signatories of the United Nations Framework Convention on Climate Change (UNFCCC).

Working Group I : The Science of Climate Change

Shanghai, 20 January 2001, IPCC Working Group I accept its contribution to the IPCC Third Assessment Report " Climate Change 2001 : The Scientific Basis" (Nertpura) Geneva, 16 February 2001, IPCC working group II accepts its contribution to the IPCC third assessment report "Climate change 2001. Impacts, Adaptation and Vulnerability".

The responsibility of Working Group I (WGI) is to assess available information on the science of climate change, in particular that arising from human activities. In performing it assessments WGI is concerned with :

Developments in the scientific understanding of past and present climate, of climate variability, of climate predictability and of climate change including feedback from climate impacts Progress in the modeling and projection of global and regional climate and sea level change Observations of climate, including past climates, and assessment of trends and anomalies; gaps and uncertainties in current knowledge.

Working Group I is guided by a Bureau, which is co-chaired by Sir John Houghton (UK) and Prof. Ding Yihui (China). Working Group I also has a Technical Support Unit (TSU) to help direct the production of reports. The TSU is housed in the Hadley Centre, which is part of the United Kingdom's Met. Office.

Working Group II: Impacts, Adaptation and Vulnerability

IPCC Working Group II accepts its contribution to IPCC Third Assessment Report:

"Climate Change 2001 : Impacts, Adaptation, and Vulnerability"

In its reports, Working Group II assesses the scientific, technical, environmental, economic and social aspects of the vulnerability (sensitivity and adaptability) to climate change of, and the negative and positive consequences for, ecological systems, socio-economic sectors and human health, with an emphasis on regional sectoral and cross-sectoral issues. Working Group II is guided by a Bureau, which is chaired by Osvaldo Canziani (Argentina) and James McCarthy (USA). Working Group II also has a Technical Support Unit (TSU) to help direct the production of reports. The TSU is housed in Washington DC.

Working Group III : Mitigation of Climate Change

The Scientific Basis : IPCC Working Group I Third Assessment Report accepted in Shanghai, 20 January 2001. Impacts, Adaptation and Vulnerability : IPCC Working Group II Third Assessment Report accepted in Geneva, 16 February 2001.

As part of the IPCC, Working Group III is charged to assess available information on the science of climate change, in particular that arising from human activities. In performing its assessments the WGIII is concerned with the scientific, technical, environmental, and economic and social aspects of mitigation of climate change. After the successful completion of the first and second IPCC assessment report on climate change in 1990 and 1995 respectively, WGIII is now in the process to work on the third assessment report (TAR) through the assessment process, WGII is also involved in preparation of special reports, technical papers, and guidance papers on cross-cutting issues and other related activities. Two IPCC Special Reports were prepared by Working Group III on Mitigation of Climate Change :

(i) Methodological and Technological Issues in Technology Transfer and

(ii) Emission Scenarios

Task Force on National Greenhouse Gas Inventories

The Task Force on National Greenhouse Gas Inventories (TFI) has a Bureau with 15 members including its two Co-chairs, and a Technical Support Unit.

Task Force Bureau (TFB)

The TFB shall provide guidance to the IPCC-NGGIP and develop it as required. The TFB consists of 15 members confirmed by the IPCC Bureau in February 1999.

Technical Support Unit

IPCC-NGGIP

The inauguration of the TSU took place on Saturday 25 September 1999 in Tokyo, Japan. Seven staff members, including four who have been internationally recruited, are now working.

The Technical Support Unit (TSU) for IPCC-NGGIP is based at the Institute for Global Environmental Strategies (IGES) in Japan. The Unit is funded by the Government of Japan. The TSU is responsible to the Task Force Bureau (TFB) which shall provide guidance to the IPCC-NGGIP and develop it as required. The TSU shall assist the Co-chairs and serve the needs of the IPCC-NGGIP. The establishment of TSU at IGES was completed in September 1999 with very substantive co-operation from the IPCC, OECD, IEA, Government of Japan and other related institutions. Seven staff members, including four, who have been internationally recruited, are now working in the TSU at IGES.

References

Anderson, I.C.and Levine, J.S. 1986 Relative rates of nitric oxide and nitrous oxide production by nitrifers, denitrifer, denitrifers, and nitrate respirers. ***Appl. Environ. Microbiol.*** 51, 938-945.

Bowen, H.I.M. 1979 *Environmental Chemistry of the Elements*. Academic Press, London.

Capoor, K., Deutz, A.M.and Ramakrishna, K. 1996 Towards Practical Implementation of Article 4.1 of the Climate treaty. Environmental Defense Fund and Woods hole Research Center. Paper presented at the U.S. environmental protection Agency's climate Analysis *Workshop held in Springfield, Virginia (6-7 June).*

Catrinus, J.J.and Munasinghe, M. 1998 *Climate Change Policy. Facts, Issues, and Analysis*. Methodology and Conceptual issues. Cambridge University Press pp 53-217.

Cicerone, R.J.and Oremland, R.S.1988**.** Biogeochemical aspects of atmospheric methane. ***Global Biogeochem. Cycles.*** 2, 299-327.

Cofer, W.R.III, Levine, J.S., Winstead, E.L.and Stocks, B.J. 1990. Gaseous emissions from Canadian boreal forest fires. ***Atmos. Environ***. 24 A, 1653-1659.

Crutzen, P.J.and Andreae, M.O. 1990**.** Biomass burning in the tropics: Impact on atmospheric chemistry and biogeochemical cycles. ***Science.*** 250, 1669-1678.

Hao, W.M., Liu, M.H.and Crutzen, P.J. 1990**.** Estimates of annual and regional release of CO_2 and other trace gases to the atmosphere from fires in the tropics, based on FAO statistics for the period 1975-1980. In J.G.Goldammer (ed.), *Fire in the Tropical Biota: Ecosystem Processes and Global Changes.* Springer-Verlag, Berlin-Heidelberg, pp. 440-462.

Levine, J.S. 1989. Photochemistry of biogenic gases. In M.B.Rambler, L.Margulis, and R.Fester (eds.), *Global Ecology: Towards a Science of the Biosphere.* Academic, San Diego, Calif., pp. 51-74.

Levine, J.S., Cofer, W.R., Sebacher, D.I., Winstead, E.L., Sebacher, S.and Boston, P.J. 1988**.** The effects of fire on biogenic soil emissions of nitric oxide and nitrous oxide. ***Global Biogeochem. Cycles.*** 3, pp. 445-449.

Lobert, J.M., Scharffe, D.H., Hao, W.M., Kuhlbusch, T.A., Seuwen, R., Warnesk, P.and Crutzen, P.J. 1991. Experimental evaluation of biomass burning emissions : Nitrogen and carbon containing compounds. In J.S. Levine (ed.), *Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications*. MIT Press, Cambridge, Mass., pp. 289-304.

Muralikrishana, K.V.S.G. and Venkatrao, M.V. 1998**.** *Our Environment,* Published by: Environmental Protection Society, A.P. India.

National Academy of Sciences 1984. *Global Tropospheric Chemistry* : A Plan for Action. National Academy Press, Washington, D.C.

Pavel, F.1999**.** Carbon emission factors of coal and lignite : analysis of Czech coal data and comparison to Europian values. *Enrironmental Science and Policy; Special issue: Greenhouse Gas Inventory quality*. Elsevier Science. Vol .2, No..3 pp. 347-354.

Reid, W.V. and Goldenberg, J.1997**.** Developing countries are combating climate change, 26 (3): 233-237.

Saji, B. 1998**.** Design of Greenbelts around Industrial Complexes to Reduce the Impact of Air and Noise Pollution, Types of Greenbelt and their Application. pp. 37-100. *M.Phil. Thesis submitted* to Pondicherry Central University, Pondicherry, India.

Saji, B. and Chacko, A.S. 2001. Green Internet or Green Environment- Combating greenhouse Gases. Paper presented for International congress of chemistry and Environment, ICEE-2001, Dec 16-18, Indore India. Abstract published in the abstracts of papers presented in the research ***Journal of Chemistry and Environment*** *a*-179 pp 64.

Sebacher, D.I., Harriss, R.C., Bartlett, K.B. 1985. Methane emissions to the atmosphere through aquatic plants. ***J. Environ. Qual***. 14, 40-46.

Sebacher, S.M. and Grice, S.S. 1986. Atmospheric methane sources: Alaskan tundra bogs and alpine fen and a subarctic boreal marsh. *Tellus* 38B, 1-10.

Second report 1997. Environmental Policy, of the Govt. of Federal Republic of Germany (Federal Ministry of Environment). *Pursuant to the UN Framework on Climate Change.* Published by: The Federal ministry for the Environment Nature Conservation and Nuclear Safety, 53048. Bonn, April, 1997, pp. 209-226.

Seiler, W.and Crutzen, P.J. 1980. Estimates of gross and net fluxes of earbon between the biosphere and the atmosphere from biomass burning. Climatic Change 2, pp. 207-247.

Sharma, B.K. and Kaur, H. 1995. *Environmental Chemistry*, GOEL Publishing House, Meerut, India, pp. 110-131.

Shukla, P.T. 1983. *Agro-forestry : a social and ecological need*. Paper presented at All India Seminar on Agro-forestry, GAU, Junagadh Campus, Junagada (GS), Dec. pp. 30-31.

Stocks, B.J., 1991. The extent and impact of forest fires in northern circumpolar countries. In J.S. Levine (ed.), Global Biomass Burning: Atmospheric, Climatic, and Biospheric Implications. MIT Press, Cambridge, Mass., pp. 197-202.

IPCC 1995. The 1995 Report of the Scientific Assessment Working Group of IPCC: Summary for Policymakers. Intergovernmental Panel on Climate Change.

IPCC 1996. IPCC Guidelines for National Greenhouse Gas Inventories; Volume I, Greenhouse gas inventory reporting instructions. Intergovernmental Panel on Climate Change.

IPCC 1996. IPCC Guidelines for National Greenhouse Gas Inventories; Volume 2, Greenhouse gas inventory workbook. Intergovernmental Panel on Climate Change.

IPCC 1996. IPCC Guidelines for National Greenhouse Gas Inventories; Volume 3, Gheenhouse gas inventory reference manual. Intergovernmental Panel on Climate Change.

IPCC 1996. Revised Guidelines for National Greenhouse Gas Inventories; Reference Manual; Volume 3. Intergovernmental Panel on Climate change.