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Air Pollution and Climate Warming on the Earth: a review

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Abstract

Air pollution is adversely affecting earth's climate. Air pollution and climate warming are closely related to each other due to common factors such as carbon dioxide (CO_2), ozone (O_3), chlorofluorocarbons, methane, nitrogen oxides, ammonia, sulphur oxides, and volatile organic compounds (VOCs) are main contributing factors to the air pollution. These air pollutants are originating from natural and anthropogenic sources. Resultantly, air contamination accelerates degradation and sustainability issues of different ecosystems around the globe. It is the need of time to control air pollution to control the climate warming and its impacts on living systems around the globe.

1. Introduction

Air pollution is caused by the pollutants which are emitted into the atmosphere. These pollutants which are released in indigenous environment also cause to regional and or global air pollution resulting heavy smoke/smog clouds causing acid rains in the environment over a large area. Substantial amounts of pollutants released into the environment are causing global environmental issues such as depletion of ozone layer. The addition of fine particles, biological molecules, and other harmful materials contaminating the Earth's atmosphere; which are causing disease, death, damage to humans and living organisms.

1.1. Primary pollutants

Major primary air pollutants include; sulfur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), volatile organic compounds, chlorofluorocarbons, ammonia (NH_4), particulate matter (PM), fine particles with persistent free radicals, toxic metals such as lead and mercury. Radioactive pollutants are produced by nuclear explosions, nuclear events, war explosives, and natural processes such as the radioactive decay of radon. All these resulting at higher level consequently leads towards air pollution which is directly affecting the climate change.

1.2. Secondary pollutants

Secondary air pollutants include photochemical smog, VOCs, peroxy acetyl nitrate and ground level ozone (O_3) formed from NO_x. Persistent organic pollutants (POPs) are also the minor type of air pollutants. The secondary pollutants are also creating the air pollution and involved in climate change up to some extent.

1.3. Sources of pollution on the earth

Generally large land areas having little or no vegetation, methane produced in the gut of animals, radon gas emitted from radioactive decay within the Earth's crust, smoke and carbon monoxide produced from wildfires all are natural sources of air pollutants. In some regions, vegetation releases significant amounts of VOCs during summer days in the environment. Moreover,

volcanic activities produce sulfur, chlorine, and ash particulates results higher PM load the air.

Burning of fossil fuel and organics in factories and waste furnaces and traditional biomass burning are different man-made sources which are severely polluting the air (Figure 1). On the other hand, mobile sources, such as motor vehicles, marine vessels e.g. submarine and aircrafts are also causing air pollution. In addition, military activities, toxic gases, nuclear weapons, rocketry and germ warfare are also contributing in air pollution. Controlled burn processes in agriculture and forest management improve air pollution caused by mobile and immobile sources.

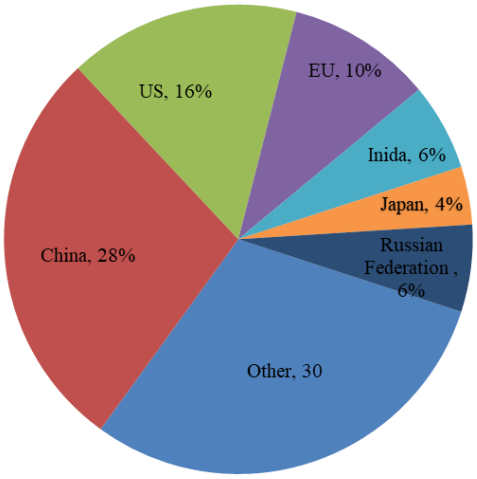

Figure 1: Global CO_2 emissions from fossil fuel combustion and some industrial processes 2011

1.4. Global anthropogenic greenhouse gases emissions by different sectors

According to World Resource Institute, worldwide primary sources of GHGs are electricity, heat, agriculture, forestry, manufacturing and transportation. All types of energy production processes are responsible for the emissions of air pollution (Figure 2).

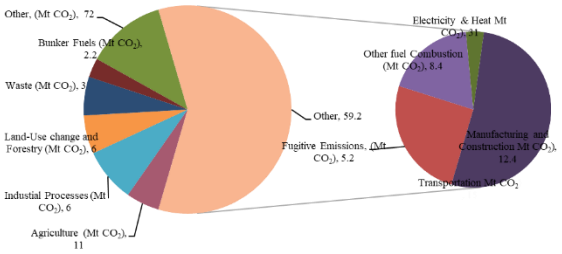

Figure 2: Contribution of different sectors in greenhouse gas emissions globally by year 2013. Major contributors are; electricity and heat (31%), transportation (15%), manufacturing (12%), agriculture (11%) and forestry (6%). All type's Energy production accounts for 72 percent of all emissions. Adopted from Climate Analysis Indicators Tool (World Resources Institute, 2017). https://www.c2es.org/content/international-emissions/

There are many phenomenon like industrial fossil fuel combustion, buildings and motor vehicles release pollutants that cause regional and local pollution. These pollutants contain PM, O_3 on ground-level along with CO_X, NOx, SOx and VOCs, however mainly carbon dioxide , nitrous oxide (N_2O) and methane (CH_4) are associated with global climate warming. Air pollutants lead to climate change and greenhouse gases which contribute to air pollution. Different studies concerning air quality modeling show that having high temperatures in the upcoming years, higher ground ozone levels will be observed in the cities of North America. It may seem challenging to handle the air pollution and climate change. But the thing is this they create from the same sources. Many steps are taken to reduce the air pollution and greenhouse gas release.

2. Particulate matter pollution

Particle pollution has both direct and indirect effects on climate change. Absorbing or scattering the light are the direct effects of particles. Climate is affected differently, by different particles, especially carbon matters. Some particles generate cooling effect like sulfates and nitrates and some of them are warmer like black carbon. Black carbon or soot particles absorbs the sunlight and emits heat in the environment which contribute in the global warming. It also causes the melting of snow and ice on glaciers. On the other hand, the particle pollution indirectly affects the climate; these can change the cloud life time and precipitation capacity of the highest clouds in the atmosphere i.e. cirrocumulus, cirrus, and cirrostratus. As scattering generally dominates, however effects intensity can differ in different regions (Forster et al., 2007). From the Sahara and Gobi deserts the clouds of dust may be noticed, in lower troposphere encircling the globe with aerosol. Particles are generally settled down from atmosphere after rainfall and settling down may require several days after they were shaped. In the stratosphere, volcanoes particles generate sulfate particles through various chemical reactions of gases from which can stay for one to several years. Ramanathan and Feng (2009) stated that GHGs are

also warming the surface and the atmosphere resulting in retreat of glaciers, sea ice and high sea level and may also have many implications on rainfall patterns and intensity in various regions of the world.

3. Air pollution and the climate change

Ozone and particulate matter remain in the atmosphere for few days or weeks causing the climate warming and minimizing such pollutants may assist to minimize the climate impacts in future. Ozone is the main factor contributing in global warming. When the ozone arises in the troposphere the impacts of climate reaches to the maximum. Sometime concentrations of ozone in troposphere are termed as global background ozone levels and its evaluated levels through lightning and global emission of CH_4, NOx, CO, and VOCs are contributing in higher global background ozone levels (Cooper, 2010).

Particle pollution has also severe direct and indirect impacts on climate. The direct effects such as ability of particles to absorb and scatter the light. The different types of particles affect the climate variably: some are warm (black carbon) while few may also have cooling effect (nitrates and sulphate). Black carbon is a dust particles component; results in global warming by absorbing the sunlight, then releasing heat to the atmosphere. The melting process is enhanced by accumulation of carbon black on snow and ice. In the alpine regions like arctic, effects of black carbon are severe. On the other hand, there may be many indirect impacts of particle pollution on climate change. Likewise, particles may affect lifetime of cloud or rain indirectly by changing the reflectivity of clouds.

3.1. Air quality and climate warming

Forster et al., (2007) stated that the regular impact for total atmospheric particles is cooling as sprinkling dominates normally, still the effects may differ dramatically from area to area. However, minimizing all sorts of productions of particulate matter obviously having health benefits. For reduction the total impact on climate the emissions approaches would be depended upon the comparative reduction in particles of various kinds.

Climate change and the air quality are closely associated. Particle pollution and ozone are mainly influenced by changes in the weather (droughts heat or waves) in 2010, EPA stated that GHG emissions can be dangerous to the public health and the public welfare. Such danger is based upon the ability of climate change to degrade the air purity. As climate demonstrate meteorological changes, determining the climate indicators in the present air quality trends is difficult. Over the last decade, there is improvement in determine the air quality parameters. It has been observed that emissions decrease quality of air and laws regulations to some extent proved ineffective to reduce harmful effects on climate.

Air pollution contains of greenhouse gases (GHGs). Major among these is CO_2 that is exhausted from cars and trucks. GHGs are the result of global warming by trapping of heat from Sun. Although GHGs are considered as a natural aspect of atmosphere of earth, but for previous 150 years, the quantity in atmosphere has increased. This increase comes from the pollutants emitted from smokestacks mainly at power plants and factories and car exhaust. The increase amount of GHGs is leading to enhanced global warming which happened over the last century.

3.2. Air pollutants and global distribution

Air pollution is a critical issue for the world and for a nation as well. Though such sorts of pollution may be in different forms, some of which are invisible, it is usually seen as emissions from exhaust, smog and dust factory. Air pollution is generated from different sources such as transportation, agriculture, industry such as factories which combust coal or fossil fuels and construction machinery using fossil fuels. Although air pollution is a problem throughout the world, the worst cases of pollution exist in Indonesia, China, South Africa, India, Mexico, Brazil and Argentina. Air pollution is now a serious issue because when the air carries polluting substance, certainly it may impact us in different patterns. Large number of diseases are associated with air pollution exposure including, asthma lung cancer and heart disease. Though every living being may be influenced by this sort of pollution, but elderly people and young children are more prone to it. Air pollution may also damage agriculture sector, different materials and this is an essential part of climate change.

Though there are several chemicals in air pollution, but the six most common types are carbon dioxide, ozone, nitrogen oxide, particulate matter, lead, and sulfur dioxides. These can be in different forms such as solids, liquids, or gases. Air

pollution is both a result of natural factors and human activities.

4. Human-caused air pollution effect on climate

Particulate air pollution which is produced by human beings impacts on climate as it may reflect and absorb the solar energy, such particles may reduce the energy which reaches at the surface of earth as heat energy. These particles are formed by human activities have contributed to an average solar energy loss at the ground level since last few decades.

By current regulations and technologies in many parts the worlds the reflection and absorption of the light by aerosol particle have been reduced. Dirt free air regulations in the US have also been diminished absorptions of particle significantly. Even nowadays, mist clouds endow with remarkable evidence of the anthropogenic impacts of particles in US; however, in atmosphere, dust accumulation is still at highest levels in many parts of Asia.

Global warming is chiefly produced by CO_2 releases and other gases adding heat to the atmosphere such as to generate electricity, power our lives and drive our cars, we burn fossil fuels. Such gases spread throughout the world and remain for longer period in atmosphere. Thus, we must keep emphasis on reducing such gases and their amount in atmosphere. However, aerosols particles in atmosphere mostly occurs near the sources of origin and don't remain in the atmosphere for longer period. In case, if we sustained release the particulates at present rates, their concentrations in atmosphere would not increase significantly with the passage of time.

4.1. Aerosol particles and climate

It is observed that the particles in atmosphere of both natural and human sources have less significant effect on climate. However, the particles can play vital role inside and outside of the clouds. The term cloud albedo refers that the increase of anthropogenic aerosols results in the formation of higher number of smaller droplets, which can influence the albedo (Twomey, 1974) and persistence (Albrecht, 1989) of clouds (Kaufman et al., 2002; Lohmann and Feichter, 2005; Forster et al., 2007). The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC) states that, to determine radiative forcing of climate during industrial period the indirect aerosol effects are the largest uncertain factor. For additional information on the level of scientific understanding for key climate-related air pollutants see Forster et al., 2007. Major contributing factor of global warming through their absorption of solar radiation is soot aerosol which is also called light absorbing, black or elemental carbon. It is common in polluted areas such as over Mexico City (MC) and other mega cities that when soot aerosols are embedded in organic matter or sulphate their optical properties are affected by their shapes and positions within their anchor particles. However, large ambiguity remains considering those variables and how they affect warming by soot. Within its host particles the shapes and positions of soot have an important effect on particle optical properties and this should be recognized as remarkably important variable during evaluating global climate change (Adachi et al., 2010).

4.1.1.Shape and size of aerosol

In pure air, particles having sizes of near about 0.1-1 micron tend to delay with the solar beam. Suspending particles having small amount of carbon are efficiently 'white'. These particles are responsible for reflection of sun energy making the earth surface and air bit cooler. For example, Pinatubo volcanic eruption in 1991 produced particles of Sulphur in the stratosphere considerable cooling about 2 years in the world (Stephen et al., 1991). Oppositely particles including considerable amounts of black carbon warm up the environments by attractive sun radiation before it come to the earth.

When water vapors follow to solvable particles of water in the same size range, it is transformed into droplets. In the air, absorption range of these globules varies from 10 by cubic centimeter to several 100/cubic centimeters. At lesser heat, few aerosols particles form cloud ice. The increased number of small drops increases cloud reflectivity that is why from aerial view, clouds present in adjacent polluted areas are mostly glowing in appearance as compare to those above clearer parts. Ice particles and water droplets are mostly white that's why they tend to imitate solar radiation, the water in condensed form also release and traps radiation of long wave, forming heat. Henceforth clouds, depending on whether the reflecting or trapping impact is effective, may have either cooling or warming impacts on local area.

The air contains volatiles, gases, dust, or fumes together termed as atmospheric aerosol

particles a large amount of them are formed by procedures occurring naturally such as eruption of volcanoes and some of them are relating to human agricultural and industrial activities. In the lowest layer of atmosphere, these suspended particles often stay comparatively close to the source of releases and before they are rained out they may remain in the atmosphere for shorter period. So, changes in the weather occur. Aerosol of light color may reproduce incoming sun rays. Aerosols can modify energy distribution from the clouds that may also change the light energy dispersal patterns in the atmosphere.

Numerous climate engineering techniques also called 'geo-engineering' practices may help in decreasing global warming suggest the use of aerosol particles in the atmospheric to revert the sunlight energy away from the earth. If the aerosol particles do not gather for long period of time in the atmosphere and gases responsible for global warming encounter in the atmosphere from many decades to centuries, it may be due to heat-catching gases that will oppose any fleeting cooling due to short lived molecules of aerosol.

4.2. Composition, sources, and removal processes of aerosol

Maximum aerosol particles in atmosphere are formed by natural processes like land erosion and grinding which are causing chemical reactions of gases, forest fires breaking waves, formation of salt-spray in oceanic biological decay of land surfaces, volcanic injection and dust at Worldwide level. But there are some particles, which have main origins like agriculture, construction, industry and transport including aviation. The aerosol particles in atmosphere structure differ extensively as per source. They may include minerals like silicon, salts predominantly sulphate and organic materials and in most conditions water as well.

The size of particles becomes larger by absorbing water vapors and other gases. In case of high relative humidity approximately 80%, small drops of water may be seen on some particles. Sometimes, this division is called cloud condensation nuclei then it is developed into cloud drops which fall to the surface with rain or snow hereafter, accumulating the particles on land or in the sea, at higher altitudes cloud particles of ice produce some insoluble particles i.e. dust (Ramanathan and Feng, 2009).

5. Carbon dioxide emissions

Human activities produce Carbon dioxide (CO_2) which is the most substantial greenhouse gas. In 2013, it is clarified that about 82% of all U.S. greenhouse gas releases by man-made activities (US EPA, 2013). Carbon dioxide appear naturally in the atmosphere due to carbon cycle. By affecting, the capability of natural sinks, anthropogenic activities are disturbing the carbon cycle. Industrial revolution and human caused emissions are the main reasons of increase emission of CO_2 from different sources in the atmosphere. Fossil fuels burning for transportation and energy are the important human actions which release CO_2 but land-use changes and industrial processes also release CO_2. Major sources of emissions of CO_2 are explained here.

Electricity is used to business, power homes and industry and it is a vital source of energy. The biggest source of productions of CO_2 in the world is the burning of fossil fuels to generate electricity. Release of gases also depends upon which type of fossil fuel is combusted. The second biggest source of CO_2 production is also the fossil fuels burnings such as diesel and gasoline to transport goods. Many industrial activities release CO_2 via burning fossil fuel. Several other phenomena also release CO_2 via actinic reactions occurring without combustion, which includes the production and consumption of mineral products like cement, the metals preparation iron and steel and chemicals synthesis. Carbon dioxide is produced by numerous microorganisms, animals and plants, and this produced CO_2 is constantly being replaced among the land surface, atmosphere and sea. Though, CO_2 emissions by these procedures need to be balanced. Since the Industrial innovation started around 1750, Human activities have remarkably resulted in global warming and climate change by adding CO_2 gases into the atmosphere (EPA, 2010).

In the 18 century, from about 280 ppm to 369 ppm, pre-industrial times concentrations of CO_2 have increased by more than 40% since 2013. In April of 2014, for the first time in history, the monthly average concentration exceeds from 400 ppm by volume at Mauna Loa. As we compare with at least 800,000 years ago, current CO_2 level is higher (IPCC, 2013).

In 2014, from the use of fossil fuels, the Global carbon (C) emissions were about 9.795 gigatons (Gt) (or 35.9 Gt CO_2 of carbon dioxide). Global carbon dioxide (CO2) emissions

from fossil fuel combustion and from industrial processes in 2013 was 35.3 gigatons CO2, which is 0.7 Gt higher than last year's record.

Table 1: Annual (2015) global carbon budget of global carbon emission

Year	Global carbon emissions		
	Total	Fossil fuels & Cement	Land-Use change
2006	9.355 GtC	8.363 GtC	0.992 GtC
2007	9.472 GtC	8.532 GtC	0.940 GtC
2008	9.666 GtC	8.740 GtC	0.926 GtC
2009	9.567 GtC	8.700 GtC	0.867 GtC
2010	9.995 GtC	9.140 GtC	0.855 GtC
2011		9.449 GtC	
2012		9.575 GtC	
2013		9.735 GtC	
2014		9.795 GtC	~ 0.9 GtC

global carbon project source data [.xlxs]

* To Convert carbon to carbon dioxide (CO_2) multiply the numbers above 3.67.

1 gigatons of carbon (GtC) contain 1 billion tons of carbon.

6. The global greenhouse gas emissions

According to the IPCC-2014 the global emissions of greenhouse gases from different sources are Carbon Dioxide 65% from fossil fuel and industrial processes, 11% from forestry and other land use, methane 16%, nitrous oxide 6% and F-gases 2% are emitting from different sources (Figure 3).

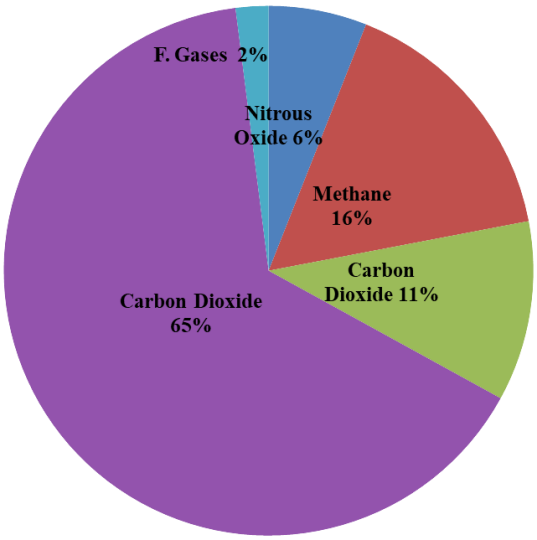

Figure 3: Global green gas emissions on the earth (IPCC, 2014)

According to the global emissions by economic sector as per IPCC (2014) electricity and heat production causing 25% of greenhouse gases, cultivation, forestation and the other land use 24%, transportation 14%, buildings 6%, industry 21% and other energy use is causing 10% of global greenhouse gases emissions (Figure 4).

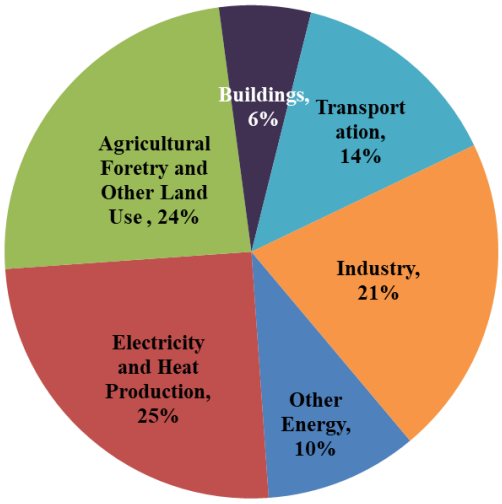

Figure 4: Global greenhouse emission by economic sector (IPCC-2014)

Different countries are emitting different amounts of CO_2 every year (Figure 5). China is the biggest source of CO_2 emissions which is emitting 28% of CO_2, united states emitting 16%, European Union 10%, India and Russian Federation 6%, Japan 4% and all the remaining countries in the world are contributing only 30% of the global CO_2 emissions (Le Quéré et al., 2015).

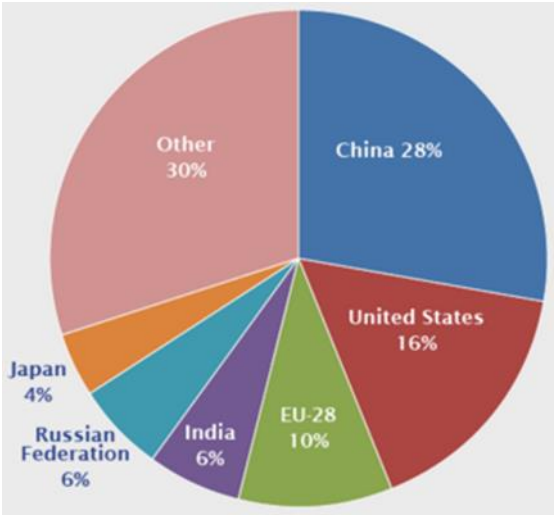

Figure 5: Global CO_2 emission by economic sector (Le Quéré et al. 2015)

7. Emission of methane (CH_4)

In United States, methane (CH_4) is the second most predominant greenhouse gas which is produced by human activities. In 2013, Methane was responsible for about 10% of all U.S. greenhouse gases that were released from anthropogenic activities like increasing in number of livestock i.e. cattle, sheep etc. and leakage from natural gas system. CH_4 is also emitted by natural

sources such as wetlands. From the atmosphere CH_4 is removed by natural processes in soil and chemical reactions. Half-life of CH_4 is much shorter than CO_2 in the atmosphere, however, CH_4 is more efficient to capture radiation as compare to CO_2. Over a 100-year period CH_4 has 25 times greater impacts on climate change as compare to CO_2. Anthropogenic activities are contributing more than 60% of total CH_4 emitted worldwide (EPA, 2010).

In the United States, the largest source of CH_4 emissions from industry are natural gas and petroleum systems. Methane is the key part of natural gas. The production, processing, storage, transmission, and distribution of natural gas emit methane in the atmosphere. Because gas is often found beside petroleum, so another source of methane emission is the manufacturing, purification, distribution, and storage of crude oil. In order to have more information, visit the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* sections on Natural Gas Systems and the Petroleum Systems.

Large volume of methane is released by domestic livestock i.e. buffalo, cattle, goats, sheep and camels, as part of their own normal digestive system. CH_4 is also produced, when animal excreta are stored or managed in pool or holding containers. As human beings intensify the farming of the animals for food so, these emissions are also assumed human-related.

Marshes are another source of CH_4 emission because in the absence of oxygen bacteria decompose the organic substances and release CH_4. Some other origins include oceans, bug, volcanoes, deposit and combustion. Production and transportation of the fossil fuels such as oil, natural gas and coal are also cause of CH_4 production. It is also produced by the degeneration of organic waste and municipal debris recycling stations.

8. Nitrous oxide (N_2O)

Nitrous oxide (N_2O) is considered for about 5% of all U.S. greenhouse gas emissions from human activities in 2013. As nitrogen cycle is part of earth so, N_2O produced by human activities like combustion of fossil fuel, agriculture, industrial processes as well wastewater management. Nitrous oxide molecules remain in atmosphere for about 114 years before being eliminated by a sink or destroyed through chemical reactions. The effect of N_2O on warming the atmosphere is about 300 times more as compared to CO_2.

Worldwide, near about 40% of total nitrous oxide is produced by human activities (EPA, 2010). In agriculture, N_2O is produced by the application of nitrogen to the soil as synthetic fertilizers. In the United States, the largest source of nitrous oxide emission is agricultural soil and during 2013, it has been accounted for about 74% of total U.S. nitrous oxide emission. In livestock feces and urine, nitrous oxide is produced by breakdown of nitrogen, which causes 5% of N_2O release in 2013. When transportation fuels e.g. motor vehicles like local buses and trucks also release N_2O. While on other hand in industry, synthesis of N_2O and adipic acid, which is used to manufacture of commercial fertilizers and to prepare fibers e.g. nylon and other synthetic products respectively, N_2O is produced as a byproduct. Nitrogen cycle also releases the N_2O as nitrogen is naturally distributed among the various components of the environment such as plants, animals, microorganisms, that live in soil and water and atmosphere. During nitrogen cycle, nitrogen exists in different forms including nitrous oxide.

9. Fluorinated gases

There are no natural origins of fluorinated gases and in contrast to other GHGs they only source of fluorinated gases are anthropogenic activities. These are produced during different industrial processes such as aluminum and semiconductor synthesis. Like other GHGs, fluorinated gases accelerate global warming and their small quantities in the atmosphere causes considerable impacts on global temperatures. Generally, these have longer half-life, and, in some cases, it may exceed thousands of years. Fluorinated gases, like another long half-life GHGs are exceptionally well distributed in the atmosphere. In the far upper atmosphere, when fluorinated gases are damaged from sunlight then only on that time we can separate them. Commonly, among all types of GHGs emitted by human activities, fluorinated gases are the most important and longest surviving.

There are four main kinds of fluorinated gases including hydro-fluoro-carbons (HFCs), per-fluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen tri-fluoride (NF_3). These gases are typically released in smaller quantities, but because they are potent GHGs. They are sometimes called as High Global Warming Potential gases (High GWP gases) because they are vital greenhouse

gases, although they are typically emitted in smaller concentrations.

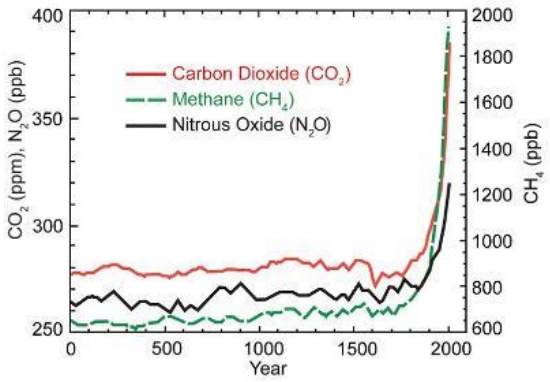

Figure 6: The greenhouse gas concentrations in the Earth atmosphere

This Figure 6 shows, over the last 2,000 years greenhouse gas (GHG) concentrations increased in the atmosphere. Since 1750 increase in concentrations of these gases are due to human activities. Concentration units are parts per million (ppm) or parts per billion (ppb), which indicates the number of molecules of the greenhouse gas per million or billion molecules of air (U.S. National Assessment, 2014).

The following figure-7 shows, trends in domestic GHG emissions of last twenty years. From 1990 to 2009, total U.S. GHG emissions have elevated 7.3% many of household GHG emissions result from electricity production and transportation.

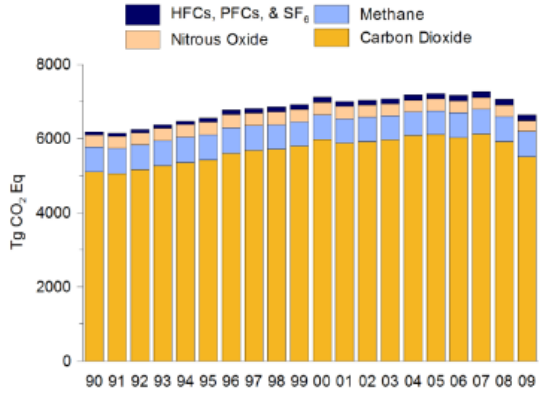

Figure 7. Domestic greenhouse gas emissions in tera-grams of carbon dioxide equivalents (Tg CO_2 eq), 1990-2009 (EPA, 2010).

10. Pollution and climate change accelerate ocean degradation

Marine biologists and climatologists concluded that a new mass destruction occasion in the oceans is accepted like previous destructions as per data record of paleontology. Among their concerns, some scientists have reported that the ocean acidification process from the absorption of carbon dioxide produced by burning fossil fuel is occurring at more rapidly than previously measured. The three forces combined in which climate change, sea dead zones and hypoxia which may create a situation same as those observed at the start of main marine species die-offs in the past, concluding that the world is near to another mass destruction incident.

10.1. Ocean changes similar to past extinction causes

The increased rate of CO_2 absorptions in the atmosphere is "much higher as compared to what was seen in the past, and it is higher than when we noticed the last important extinction event on planet earth. Scientists claim that the rate at which CO_2 is being trapped by the oceans is now greater than it was at a point roughly before 55 million years ago, when paleontologists and geologists say up to 50% of deep sea species have become extinct. Current studies have also suggest that the traces of detergent pollution in Antarctic waters and Arctic which show that seaside runoff is much more widespread and universal than many had hypothetical. Previously occurred mass marine extinction events were "accompanied by huge disturbances in the carbon cycle and we are now observing some signs of those types of disturbances now.

Air pollution and weather changes are correlated. Health of human beings and ecosystems are affected by air pollution and it also affects the earth climate. As sunlight energy reaches to the earth, it absorbs a small quantity of heat energy and releases the remaining return space in the form of heat energy. Earth surface temperature is dependent on the balance of entering and leaving energy. The GHGS like CO_2 and CH_4 in atmosphere can capture this heat energy and do not release heat. In EPA (2009), in the Clean Air Act, those GHGs comprise air pollution which is highly harmful for public health and welfare.

11. Sinking black carbon emissions benefits both health and climate

A recent estimation recommends that reducing black carbon releases would help to avoid number of premature deaths mainly in developing countries as well as will help to meet safe targets of mitigation for climate change. When fuels having carbon are burned, incomplete combustion results in CO_2 emission and such other pollutants, as well

as particulate matter that contain particles heating up or cooling the climate earth by reflecting or absorbing the radiation from sun. One category of PM, elemental carbon remains in the atmosphere relatively with short half-life, but it tends to absorb solar radiation powerfully. Additionally, particulate matter is main local air pollution source; however, their concentrations may differ depending on the combustion source. Exposure to particulate matter can have a key health effect. Such conditions apply primarily to the poor countries where, like high dependence on solid fuel, such as wood for purpose of cooking is used. Estimates shows that indoor smoke pollution due to black carbon was responsible for about 1.8 million deaths in developing countries. Polluting industries and older vehicles also lead to high pollution of black carbon mainly in urban air of developing countries.

11.1. Climate impacts on air pollution can increase respiratory disease

Many evidences from different studies of modelling suggest that climate change is possible to raise concentrations of ozone which is important air pollutant in urban areas and causes breathing problems. One most important thing we should have to considering that burning of fossil fuel should be decreased to care for the health of both present and future generations. Climate can affect the atmospheric state and it also has impact on flow and development of air pollutants which may cause many atmospheric layers height and chemical reactions rate in the air. Therefore, there is confusion about this matter that climate change may change the illness and mortality burden related air pollution. But it is very difficult to find out accurately that in future what will be impacts of climate change on quality of life and human health. Many researchers find out on basis of available literature that the impacts of air quality on health and the costs of climate change. There are only minor studies which indicate the ozone concentration in a changing climate and fewer regarding concentrations of particulate matter. Extra research is also required to improve acceptance of possible influences of air pollution on climate change and health problems causing due to air pollution.

12. Measurement of air pollution

Air pollutants like water pollutants, are expressed in ppm or micrograms per cubic meter ($\mu g/m^3$). For water, 1ppm = 1 part of pollutant in 1 million parts of water i.e., 1 mg per 10^6 mg i.e., 1 mg/L. However, for air it is not so. One gram-mole of any gas at STP conditions occupies the same volume of 22.4 liters. Thus 64 grams of SO_2 mg i.e., 1 mg/L. However, for air it is not so. One gram-mole of any gas at STP conditions occupies the same volume of 22.4 l, thus 64 g of SO_2 or 30 grams of NO or 46 grams of NO_2 or 48 grams of O_3. All these occupy the same volume of 22.4 liters at 0˚C temperature and 760 mm of Hg pressure. The volume occupied is 24.5 liters at 25˚C and 760 mm Hg pressure.

If the molecular weight of a gas is M then, M grams of it occupy:

$$\mathbf{22.44 \times 10^{-3} m^3 \text{ at } 0^{\circ}C \text{ and } 24.5 \times 10^{-3} m^3 \text{ at } 25^{\circ}C}$$

$$\mathbf{1ppm = \frac{1\ part\ of\ gas}{10^6\ parts\ of\ air} = \frac{1 m^3 of\ gas}{10^6 m^3\ of\ air}}$$

$$\mathbf{= \frac{M / (22.4 \times 10^{-3}) grams}{10^6 m^3} = \frac{M}{22.4} \times 1000\ \mu g/m^3 at\ 0^{\circ}C}$$

$$\mathbf{= \frac{M}{24.5} \times 1000\ \mu g/m^3 at\ 25^{\circ}C}$$

The conversion factor may be written in a general form as follows:

$$\mathbf{1ppm = 44.64\ M \times \frac{273}{273 + T} \times \frac{P_2}{P_1} \mu g/m^3\ where}$$

M = Molecular weight of the pollutant (gas)
T = Temperature of gas in ˚C
P_1 = Pressure at STP conditions and P_2 = Pressure of gas (air)

The ppm-$\mu g/m^3$ conversion factor for different gases is given in table 2.

Table 2: conversion factor for different gases

Pollutant	Molecular Weight, M	ppm-$\mu g/m^3$ conversion factor 0˚C, 760 mm	25˚C, 760 mm
O_3	48	2142	1960
SO_2	64	2860	2620
CO	28	1250	1145
CO_2	44	1964	1796
HC (as CH_4)	16	715	655
NO	30	1343	1230
NO_2	46	2054	1880
$CH_3(CO)O_2NO_2$ (PAN)	121	5348	4945

13. Conclusion

Environmental air pollution and climate change are associated with each other. Climate change is affecting on living organisms around the globe. In this regard we have to decrease concentration of GHGs such as carbon dioxide, ozone and

chlorofluorocarbons, etc. which are main contributing factors for the climate variability.

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