ENVIRONMENTAL EFFECTS OF BURNING FOSSIL FUELS

***K.Saritha Rani**,
Department of Chemistry Govt. Degree College for Women (A), Guntur.
***Corresponding author: Email: saritha_karnam@yahoo.co.in**

ABSTRACT

Over the past quarter century, we have come to realize that there is more to life than material goods and services, that "some of the best things in life are free." The pleasure we derive from breathing fresh air, drinking pure water, and enjoying the beauty that nature has provided is priceless and must not be sacrificed. Moreover, losing them will lead directly or indirectly to incalculable economic losses. We have come to appreciate the importance of our environment.

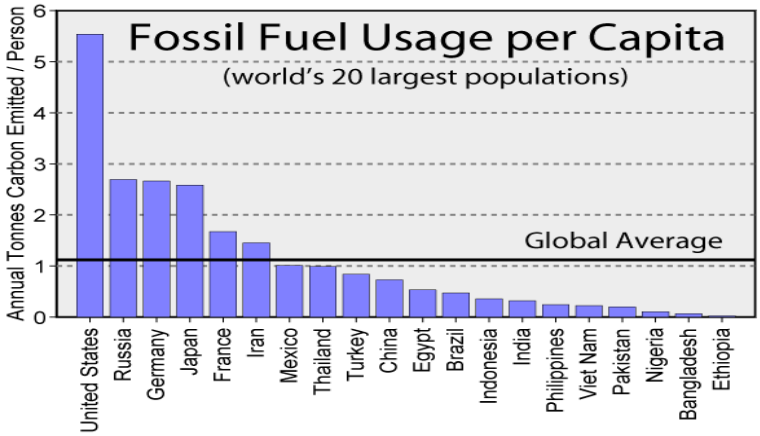
Fossil fuels are the largest greenhouse gas emitters in the world, contributing 3/4 of all carbon, methane and other greenhouse gas emissions. Burning coal, petroleum and other fossil fuels at extremely high temperatures (combustion) is the primary means by which electricity is produced, but also leads to heavy concentrations of pollutants in our air and water. Here are some eye-popping statistics from the Energy Information Administration:

- 3.2 billion tons of additional carbon dioxide annually.
- More than 2.5 million metric tons of carbon is produced by power plants.
- 98 percent of U.S. energy production comes from non-renewable sources, a.k.a. fossil fuels.
- The U.S. consumes more than 20 million barrels of oil per day, with more than one million tons of coal consumed annually as well.

The increased awareness surrounding global warming and the importance of renewable energy is vital, but the fact remains that fossil fuel production and consumption has hundreds of years of history, and the use of renewable energy is still in its infancy. Much has been said and written about environmental problems with nuclear power. But in this article, we consider the wide variety of environmental problems in burning fossil fuels — coal, oil, and gas. They probably exceed those of any other human activity. The ones that have received the most publicity in recent years have been the "greenhouse effect," which is changing the Earth's climate; acid rain, which is destroying forests and killing fish; and air pollution, which is killing tens of thousands of American citizens every year, while making tens of millions ill and degrading our quality of life in other ways. We will discuss each of these in turn, and then summarize some of the other problems that have drawn lesser attention.

1. INTRODUCTION

Fossil fuels as the name suggests are derivatives of plant and animal fossils that are million years old. These are primarily formed from the remains of the decayed plants and animals of the carboniferous era. The three fuel sources coal, natural gas and oil/petroleum helps to meet the energy and electricity demands of today's world. The demand for energy will never be in the declining graph. Industrial revolution has shown the way and it's still going on.



Coal, oil, and gas consist largely of carbon and hydrogen. The process that we call "burning" actually is chemical reactions with oxygen in the air. For the most part, the carbon combines with oxygen to form carbon dioxide (CO_2), and the hydrogen combines with oxygen to form water vapor (H_20).

2. POLLUTION

A *pollutant* is a substance – usually a harmful one – that is not a natural constituent of the environment. If it does occur naturally, it is present in abnormally high concentrations. The principal air pollutants resulting from fossil fuel combustion are the following:

(a) carbon monoxide;
(b) the oxides of sulfur, SO2 and SO3 (represented as SOx);
(c) the oxides of nitrogen, NO and NO2 (NOx); and
(d) 'particulates', consisting primarily of very fine soot and ash particles.

Air pollution may result also from unburned hydrocarbons; these either pass through energy conversion devices without burning or escape into the air by evaporation before they can be burnt.

For many years, lead compounds contributed to air pollution, but the nearly complete elimination of 'leaded' gasoline has reduced this problem significantly.

These *primary* pollutants can further interact with the environment to generate additional deleterious effects. Examples of these effects (*secondary* pollutants) are acid rain and smog, the greenhouse effect and the high ozone levels in the air we breathe. (This last effect should not be confused with the ozone layer depletion, which is also becoming an environmental problem but has no direct relationship with fossil fuel utilization.)

2.1. Primary Air Pollutants

2.1.1. Carbon Monoxide: Carbon monoxide (CO) is a product of incomplete combustion of any fuel. It is both a highly poisonous gas and the principal constituent of photochemical smog.

The main culprits of CO pollution are the urban automobiles and transportation vehicles in general. It has been estimated that some 100 million tons of CO are emitted every year in the U.S. Use of cold engines – the result of frequent short trips – and of improperly tuned engines simply does not allow the carbon in gasoline to burn completely into carbon dioxide. As much as 80% of today's automobile emissions occur during cold starts that burn fossil fuels cannot be turned off and on so easily, and their contribution to this pollution problem is insignificant.

Health effects associated with human exposure to carbon monoxide:

CO concentration (parts per million)	Duration of exposure (hours)	Effect
100	10	Headache
300	10	Nausea, unconsciousness
600	10	Death
1000	01	Unconsciousness
1000	04	Death

2.1.2. Sulfur Oxides: Sulfur oxides arise during combustion from oxidation of sulfur in sulfur containing fuels (some coals and some petroleum-based products). The principal product is sulfur dioxide:

S (in fuel) + O2 --> SO2

Sulfur dioxide has an annoying odor and it irritates the eyes and respiratory tract. Still, SO2 itself is not highly dangerous. However, when it is released to the atmosphere, it can react with oxygen in the air to form sulfur trioxide:

2 SO2 + O2 ® 2 SO3

Health effects of sulphur oxides:

- Sulfur trioxide irritates the mucous membranes of the respiratory tract.
- A concentration of 1 volume of SO3 in a million volumes of air (one part per million or 1 ppm) is enough to cause coughing and choking.
- Sulfur trioxide dissolves in water to form sulfuric acid, which is a strong acid capable of corroding or destroying many materials.
- Sulfur trioxide can absorb moisture from the atmosphere to form very fine droplets of sulfuric acid. Inhalation of these droplets can harm the respiratory system.
- Chronic exposure leads to a much greater likelihood of suffering from bronchitis.
- Sulfur trioxide can also dissolve readily in rain drops, and fall to the earth as acid rain.

2.1.3. Carbon dioxide: Burning fossil fuels releases significant quantities of carbon dioxide, aggravating climate change. Although it gets less attention these days, combustion also emits volumes of pollutants, which can cause a variety of illnesses. The most extensive consequences across the U.S. are noted below.

U.S. Health Burden Caused by Particulate Pollution from Fossil-Fueled Power Plants	
Illness	Mean Number of Cases
Asthma (hospital admissions)	3,020
Pneumonia (hospital admissions)	4,040
Asthma (emergency room visits)	7,160
Cardiovascular ills (hospital admissions)	9,720
Chronic bronchitis	18,600
Premature deaths	30,100
Acute bronchitis	59,000
Asthma attacks	603,000
Lower respiratory ills	630,000
Upper respiratory ills	679,000
Lost workdays	5.13 million
Minor restricted-activity days	26.3 million

2.1.4. Nitrogen Oxides: Nitrogen oxides have two sources. *Fuel NOx* is produced when nitrogen atoms chemically combined with the molecules of the fuel are oxidized during the combustion process to form nitric oxide:

2 N (in fuel) + O2 ® 2 NO

In addition, *thermal NOx* is produced in some combustion processes that operate at such high temperatures that nitrogen molecules in the air are oxidized to nitric oxide:

N2 (in air) + O2 ® 2 NO

(Remember that air is 79% N2 and 21% O2.) When the nitric oxide is emitted to the environment, it readily reacts with oxygen in the air to form nitrogen dioxide:

2 NO + O2 ® 2 NO2

Nitrogen dioxide is a noxious gas that can cause inflammation of the lungs and, at high concentrations, even death. In addition, nitrogen oxides will react further with water and oxygen to form nitric acid:

4 NO2 + 2 H2O + O2 ® 4 HNO3

Like sulfuric acid, nitric acid is a very strong acid that easily corrodes or attacks many materials. Nitric acid is also a component of acid rain.

2.1.5. Particulate Matter:

- Particulate matter emissions (soot and fly ash) are a concern because they can contribute to long-term respiratory problems.
- Many of these particles are extremely small, of the order of 10 micrometer or less, and they are thus suspended in the air we breathe. After inhaling them, they get trapped in the very thin air passages inside the lungs. Over a period of years this reduces the air capacity of the lungs. Reduced air capacity leads in turn to severe breathing and respiratory problems.
- Chronic asthma or emphysema can result, as well as increased general susceptibility to respiratory diseases.
- To make things worse, these particles may carry along small amounts of hazardous trace elements or potentially carcinogenic organic molecules.
- Particulate matter is also an aesthetic nuisance. Areas with high concentrations of air-borne particulate matter are more likely to experience fogs, because these particles are preferred nucleation sites for water droplets. Smoke and soot are also very undesirable aesthetically.

2.1.6. Soot:

- Soot is formed during combustion when the supply of oxygen is insufficient for complete conversion of carbon to carbon oxides. Its formation is mainly a problem in the combustion of liquid and solid fuels (oil, coal, or wood), because molecular-scale mixing of fuel and oxygen is not as easy here as it is in the combustion of natural gas.
- The most familiar experience with soot is the powdery "black stuff" inside chimneys. It can also be observed as 'smoke' (gas laden with soot and thus rendered visible) which billows from the exhausts of diesel-fueled trucks accelerating on the highway.
- Fly ash is the inorganic, non-combustible residue of pulverized coal combustion.
- These solid particles are very small and very light, and as a result are swept through the boiler into the atmosphere.

2.1.7. Unburned Hydrocarbons:

- Unburned hydrocarbons represent another source of air pollution associated with the use of fossil fuels (especially gasoline), even though they are not a result of combustion. Much of the emission of unburned hydrocarbons to the air occurs as a result of evaporation from fuel tanks (remember the smell of gasoline during your last fill-up?) and as a result of leaks or spills. Taken individually, these events seem trivially small.
- But on any given day millions of vehicles are being refilled with gasoline. In addition, if you drive a car whose engine is poorly tuned, a significant fraction of gasoline sweeps right through the engine and ends up unburned in the exhaust system.
- To understand how this happens and also to understand the related phenomenon of soot formation, let us consider four possible fates of heptane, C7H16, in an engine.

Reaction	Oxygen/fuel ratio
C_7H_{16} + 11 O2 ® 7 CO2 + 8 H2O	11:1
2 C_7H_{16} + 15 O2 ® 14 CO + 16 H2O	7.5:1
C_7H_{16} + 4 O2 ® 7 C + 8 H2O	4:1
C_7H_{16} ® C_7H_{16}	0:1

- As the ratio of oxygen to fuel (or air to fuel) decreases, the products change from the desired carbon dioxide to the undesired carbon monoxide and then to soot (which is almost pure carbon) or unburned heptane. When an engine is operating on a high value of air/fuel ratio, we say the engine is running *lean.*

2.2. Secondary Air Pollutants:

- Sulfur oxides and nitrogen oxides combine with water to form *acid rain.*
- Natural rainfall has a pH of 5.6. In contrast, rain falling over much of the eastern United States in the summer typically has a pH of 4 or less. As the acidity of lakes and streams increases, the water can eventually become too acidic to support the life of fish and other aquatic organisms. Acid rain falling on land can acidify the soil, harming

crops and forests. For example, more than 50% of the red spruce in the Adirondacks, the Green Mountains in Vermont and the White Mountains in New Hampshire have died in the past 25 years.

- *Smog* is another secondary pollutant. This term was developed to describe a substance that is a hybrid of smoke and fog. The SOx aerosols are one source of smog formation.
- Modern-day smog is often referred to as 'photochemical' smog. It is produced by complex, sunlight-stimulated chemical reactions among the components of automobile exhaust
- An estimated 80% of smog today arises from vehicle exhausts. Not only does smog smell bad and obstructs vision, but both short-term and long-term exposure to it may be hazardous.
- Eye irritation develops upon short-term exposure. Chronic pulmonary diseases, asthma, bronchitis and even lung cancer may result from longer-term exposure; in addition, paint and fabrics slowly deteriorate during long-term exposure.
- Finally, the *ozone* level in the air needs to be mentioned. Again, this ground-level ozone should not be confused with the depletion of the ozone layer in the upper atmosphere, which is increasing the exposure of earth's surface (and our skin) to harmful ultraviolet radiation. This depletion is caused primarily by chemicals such as chlorofluorocarbons (CFCs), which are used as refrigerants in air conditioners, refrigerators, etc.

2.3.1. Ground-level ozone (O_3)

- It is a secondary air pollutant and an important smog constituent. It is formed by complex chemical reactions of primary pollutants with oxygen (O2). Its effect depends on its concentration in the air.
- At low concentrations, it can be beneficial, as in fresh air after a storm. At higher concentrations, it is an irritant. Its concentration rises proportionately with that of primary pollutants and it is often reported as an indicator of smog accumulation in a city.
- The energy and fuels industry (primarily vehicles and fuel filling stations) accounts for about 50% of groundlevel ozone; the rest comes from other industrial and nonindustrial uses.

3. AIR POLLUTION CONTROL

- The Clean Air Act of 1970 and its amendments (in 1977 and 1990) are crucial milestones in air pollution control history. They are a political response to the increasing concern of society about the environmental impact of fossil fuel utilization.
- Ironically, it is precisely this fossil fuel utilization that has provided society – and especially the industrialized nations – with the technical and economic means to achieve air pollution control. (Who was it that said, "Thou shalt bear the seeds of thy own destruction"?)
- Unquestionably, the regulation of emissions has brought about a significant improvement in air quality in the U.S., especially in large cities. Since the early 1970s, annual emissions of SO2 have been decreasing and those of NOx have not increased.
- The improvement has been due, in part, to the efforts of the Environmental Protection Agency (EPA). The following table summarizes the current National Ambient Air Quality Standards, which the Environmental Protection Agency has a mandate to enforce.
- National Ambient Air Quality Standards (NAAQS)

Pollutant	Averaging time	Primary standard levels
Particulate matter	Annual	75 µg/m ^{3}
(10 µm in size)	24 hours	260 µg/m ^{3}
Sulfur oxides	Annual	80 µg/m ^{3} (0.03 ppm)
	24 hours	365 µg/m ^{3} (0.14 ppm)
Carbon monoxide	8 hours	10 mg/m^3 (9 ppm)
	1 hour	40 mg/m^3 (35 ppm)
Nitrogen dioxide	Annual	100 µg/m ^{3} (0.05 ppm)
Ozone	1 hour	240 µg/m ^{3} (0.12 ppm)
Hydrocarbons	3 hour (6-9 A.M.)	160 µg/m ^{3} (0.24 ppm)
Lead	3 months	1.5 µg/m ^{3}

4. GREENHOUSE EFFECT

- The burning of all carbon-containing fuels inevitably produces huge quantities of carbon dioxide. With efficient combustion, all of the carbon in the fuel is converted to carbondioxide. Carbon dioxide is a desired product of fuel combustion. It is also a normal constituent of air, at an average concentration of 0.0315% (315 parts per million). So it is not usually considered to be a primary air pollutant. It better not be, because we drink it all the time, in sodas.
- For every 100 units of radiant energy that reaches the atmosphere, 25 are reflected from the clouds and another 25 are estimated to be absorbed by the clouds. Of the 50 units that reach the Earth's surface, 5 are reflected and 45 are absorbed. The absorbed radiation is re-emitted from the surface back toward space as infrared radiation (heat).

However, because of the presence of CO2 and other infrared-absorbing gases , it is trapped and returned back to the surface, as an estimated 88 units of energy (greenhouse effect).

- The burning of fossil fuels is estimated to contribute about 50% of the gases that are thought to be responsible for the greenhouse effect (global warming).Other culprits are methane (that might escape from natural gas reservoirs, or is vented from coal mines, or is produced by anaerobic fermentation in landfills and by cows), nitrous oxide (yet another nitrogen oxide produced during fossil fuel combustion), and chlorofluorocarbons.
- Deforestation is also a problem because it decreases nature's capacity to absorb, by photosynthesis, the CO2 already present in the atmosphere.

5. CONCLUSION

In today's world air pollution has become a global problem. A heightened concern for the environment, combined with increasing sophistication in tracking and modelling air currents, has led to the realization that local air and water may be contaminated by pollutants emitted many miles away. Indeed, this realization has resulted in inter-regional and international tensions regarding air pollution. Therefore different alternative sources of energy such as nuclear, hydroelectric, solar, wind, and geothermal have to be used.