

Issues of Industrial Pollution: Global Warming, Threats to Biodiversity

Subject	Lesson/Chapter Name
Political Science	Issues of Industrial Pollution: Global Warming, Threats to Biodiversity

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1.1 Understanding Industrial Pollution

We have already studied in the Chapter on Environment and Sustainable Development that the presence of unwanted or harmful substances in either of the four components of the environment (viz. atmosphere, hydrosphere, lithosphere and biosphere) is known as environmental pollution. The unwanted or harmful substances are known as pollutants. **Industrial pollution** is a type of environmental pollution which occurs when the source of pollutants is an industrial process or processes.

Modern lifestyle is heavily dependent on industrial technologies. The goods and raw materials we use in our daily lives are all produced using different industrial technologies. The industrial sector is also a very important asset for the economic growth and development of any nation. This is because industrial development is almost always followed by economic development, improvement in the standard of living and poverty alleviation.

While the advent of industrial technology has no doubt made our lives more comfortable, it is also leading to significant environmental degradation and global warming. Industrial development often takes place with huge environmental costs and leads to pollution and degradation of our air, water and land.

This is largely because of the following three reasons; 1) the industrial sector is predominantly powered by the fossil fuel based energy sector, 2) a lot of by-products generated and released during industrial processes are actually environmental pollutants and 3) most of the finished products from the industrial processes are non-biodegradable in nature and add to the waste load after they have been utilized.

Biodegradable and Non-biodegradable Pollutants

Every substance around us can be categorized into either biodegradable or non-biodegradable. This is also true for environmental pollutants and is especially important in the understanding of the breakdown of these pollutants. Biodegradable substances are those substances which are capable of being decomposed by bacteria or other living organisms. Environmental pollutants which are biodegradable in nature generally do not pose any long-term threat to the environment. Kitchen waste is a type of environmental pollutant which is biodegradable in nature.

Non-biodegradable substances are those which do not decompose or cannot be broken down by any known biological process. Non-biodegradable pollutants generally accumulate in the environment and may be categorized as persistent environmental pollutants. Plastic, heavy metals and radioactive waste are examples of non-biodegradable pollutants.

It may be mentioned here that just because biodegradable pollutants can be decomposed in nature does not mean that they do not pose any problem. Large-scale generation of kitchen waste in megacities like Delhi is already posing a big challenge to efficient municipal waste management.

It is no wonder then that the pollution of our environment has been steadily increasing since the industrial revolution. Consequently, the modern environmental movement began along with the advent of industrial revolution. Industrial revolution began in Great Britain sometime around the 1760s. Towards the end of the eighteenth century, its impact on the

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environment began to be felt largely in the form of global warming and loss of biological diversity. Interestingly, a historical (1854-2010) review of anthropogenic carbon dioxide and methane emissions reveals that nearly two-third of man-made global warming emissions have been caused by just 90 global companies (Heede, 2014).

Industrial pollution today has become one of the major challenges facing the 21st century. Substances produced and used by the industrial sector are synthetic materials like plastic, polythene or inorganic chemicals and pesticides like dichlorodiphenyltrichloroethane (DDT) which are non-biodegradable and accumulate in our immediate environment. Once released into the environment, these substances have the potential of causing considerable damage to public health.

There are many case studies where industrial pollution has led to large-scale loss of human life and property. One of first such incidents was reported from around the Minamata Bay Area in Japan in early 1950s. The factory of a company called Chisso Corporation, one of the first pesticide and chemical manufacturing companies in Japan, was located close to the Minamata Bay. The factory became a *point source* of pollution for the Minamata Bay which proved to have devastating consequences for the local residents.

Continuous dumping of mercury and other heavy metals as waste water in the Minamata Bay by Chisso Corporation caused widespread pollution of the Minamata Bay. Local inhabitants who consumed fish and other edible aquatic organisms available in the Minamata Bay got severely affected by mercury pollution. Thousands of people developed various deformities and even lost their lives. The incident was so significant that the resultant disease from consuming mercury laden fish came to be known as *Minamata disease*.

Point and Non-Point Sources of Pollution

We have already read that pollution is the introduction of contaminants into the environment. The contaminants may be released into the air, water or soil. For the purpose of environmental management, the sources of pollution are broadly classified into two categories. These are: 1) Point sources and 2) Non-Point sources.

Point sources are the organized sources of pollution where the pollution load can be easily measurable and actual source can be identified. For example, *Najafgarh* drain releases its sewage in River Yamuna in North Delhi. The *Najafgarh* drain is therefore one of the point sources of pollution for River Yamuna. Industrial chimneys, industrial effluent outlets are other examples of point sources of pollution. Since the sources are identified, management and mitigation measures can be easily designed.

Non-point sources are non-measurable sources of pollution and this pollution comes from diffuse sources. The pollution of River Yamuna due to the run-off from agricultural fields carrying pesticides and fertilizers is an example of non-point source of river pollution. Atmospheric deposition, sediments from improperly managed construction sites and floral offerings in rivers are some other examples of non-point sources of pollution.

Accidental disasters taking place in the industrial sector also cause significant environmental pollution. Nuclear disasters such as the ones that took place in Three Mile Island (United States of America) in 1979, Chernobyl (Ukraine) in 1986 and Fukushima (Japan) in 2011 killed and crippled large number of people due to the resultant exposure

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to nuclear radiations. These disasters contaminated the environment not just for the present but also for the future generations.

The Bhopal Gas Tragedy is another example of an industrial accidental disasters. It is in fact one of the worst industrial accidental disasters that the world has witnessed in recent times. The disaster took place on the night of 2nd December, 1984 with the accidental release of poisonous methyl isocyanate (MIC) gas from the Union Carbide (now Dow Chemicals) pesticide manufacturing plant located in Bhopal, India. Thousands of people died as a result of the gas leakage and the survivors continue to fight for justice till date (Fig 1).



Figure 1. A memorial in Bhopal installed in the memory of those killed and disabled by the 1984 toxic gas release from the Union Carbide Factory. (Source: http://commons.wikimedia.org/wiki/File:Bhopal-Union_Carbide_1_crop_memorial.jpg Accessed on 20/03/2015 at 09.00 am)

Web Resource: <http://www.bhopal.net/what-happened-in-bhopal>

The Bhopal Gas Tragedy, one of the worst industrial disasters in modern day, continues to be an issue of debate. This is because the victims were never given any justice and the environment around the factory continues to remain polluted. The above link provides more information about the disaster and the ongoing international campaigning on this issue. A video presentation on Bhopal Gas Tragedy can be viewed here: <https://www.youtube.com/watch?v=HXDOzMRrKlo>

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Following are some specific examples of direct impacts of industrial pollution on human civilization:

River Pollution

River pollution results from factories and industrial units releasing their waste water into nearby rivers and streams. The waste water from industrial processes usually contains pollutants such as heavy metals, detergents, organic and inorganic chemicals as well as biological impurities which leads to pollution of the rivers and streams.

Sometimes hot water is released into the rivers as an industrial by-product (e.g. from thermal power plants) which causes thermal pollution and kills fish and other organisms. A prominent reason for the pollution of River Ganga is the industries located along its banks.

Acid Rain

Acid Rain is a very serious environmental problem being faced by the world today. The burning of coal and other fossil fuels releases gases such as sulphur dioxide and nitrogen oxides in the air. When these gases react with rain water in the upper atmosphere, they form acidic solution which falls down as acid rain. Acid rain causes corrosion of the surface where it falls, destroys crops and affects soil, surface water and ground water resources.

Acid rain in Agra is believed to have caused the yellowing of the Taj Mahal. This was taken very seriously by the Supreme Court of India and factories as far away as Mathura were asked to relocate or shut down to stop the emissions of sulphur dioxide and nitrous oxides and prevent acid rain.

Web Resource: <http://www.epa.gov/acidrain>

Further information on the causes, effects and control measures of acid rain can be read at this link.

Smog

The word *smog* is coined by fusing the word *smoke* with *fog*. When fog in the air gets mixed with smoke emitted from factories and industrial units, it results in the creation of smog. Smog is thus a type of air pollution and was first experienced in the city of London, the place which is considered to be the origin of industrial revolution. The London smog is believed to have killed thousands of people when it first reported to occur in the 1950s.

The occurrence of smog is a serious health hazard and is found to take place more often near industrial units and busy roads. Delhi, which has now been declared as one of the most polluted cities in the world, also witnesses such smog events (Fig. 2).

Soil Pollution

Soil pollution results from the dumping of industrial waste (solid and liquid) on open ground surface. Waste from factories may contain heavy metals and other chemicals which affect the soil's fertility and makes it barren.

Soil pollution is indirectly caused by the industrial sector through the manufacturing of pesticides and fertilizers. These chemicals are then sold to the farmers who apply them in their agricultural farms. Excess use of pesticides and fertilizers in 'green revolution' states of Haryana and Punjab has led to a significant degradation of soil and ground water in these two states.

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When excess fertilizers and pesticides, which are sprayed in the agricultural fields, wash of from the fields (due to rainfall run-off) to nearby ponds, it leads to the phenomenon of *Eutrophication*.



Figure 2. Occurrence of Smog in Delhi.

(Source: <http://delhigreens.com/2015/03/02/monday-feature-green-news-and-media-roundup-for-week-09-2015> Accessed on 20/03/2015 at 09.00 am)

Eutrophication

As described above, sometimes the fertilizers sprayed in agricultural fields are washed away due to rainfall into the nearby water bodies such as ponds or lakes. Since the function of fertilizers is to promote plant growth, these chemicals cause excessive growth of green plants and algae often resulting in algal blooms.

The green plants consume all the dissolved oxygen and other nutrients and block sunlight from reaching the other aquatic organisms like fish, leading to the death of fish and all the other aquatic animals. Thus, eutrophication leads to the disruption of the normal functioning of any aquatic ecosystem.

Marine Pollution

Marine pollution usually occurs when any kind of waste enters marine water bodies like seas and oceans. Industrial pollution is a major contributor to marine pollution especially in the case of oil spills. Oil spills occur either as a result of accidental disasters such as when an oil carrier ship breaks down in sea, or from leaking pipelines and oil tankers.

The oil that spills in the open waters is a toxic pollutant for marine life and affects every organism that comes in its contact (Fig 3).



Figure 3. Pelican bathed in oil as a result of an oil spill.

(Source: https://commons.wikimedia.org/wiki/File:Oiled_Pelicans.jpg Accessed on 20/03/2015 at 09.00 am)

Ozone Layer Depletion

The atmosphere of the Earth includes a protective ozone layer around it which prevents the harmful radiations of the sun from reaching the Earth's surface. This layer is known as the Ozone Layer and it exists in the Stratosphere part of the atmosphere. Industrial processes create synthetic chemicals like Chlorofluorocarbons (CFCs) which are now known to have a damaging effect on the Ozone Layer.

These CFCs were manufactured to be used as refrigerants, propellants (in aerosol applications) and in solvent. The impact of CFCs and related compounds (now known as Ozone Depleting Substances or ODS) was such that their large-scale production and use led to the creation of a hole in the Ozone Layer.

Web Resource: <http://ozonewatch.gsfc.nasa.gov>

View the latest status of Ozone hole over the Antarctic at this link.

After the discovery of the Ozone hole in the 1980s, the world leaders got together and decided to phase out the use of CFCs and replace them with more environment friendly chemicals. The international treaty which led to the successful phasing out of ODS is known as the Montreal Protocol. Since the threat from the Ozone hole was very alarming, the Montreal Protocol is one of the most successful international protocols, ratified by all the nations of the world.

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Global Warming

The increase in the average global surface temperature of the Earth is known as global warming. Global warming results from an increase in the concentration of greenhouse gases in the Earth's atmosphere. Greenhouse gases (e.g. carbon dioxide, methane, etc.) are natural components of the atmosphere and keep the atmosphere warm. However, excessive greenhouse gases cause excessive warming which is referred to as global warming.

Global warming is one of the most important environmental challenges of the present day and it leads to climate change. The addition of the excessive greenhouse gases in the atmosphere is largely attributed to industrial pollution and human activities such as burning of fossil fuels and destruction of forests and biodiversity. We will study more about global warming later in this Chapter.

Biodiversity Loss

The sum total of all life forms on Planet Earth are collectively known as biological diversity (or biodiversity). Industrial pollution affects biodiversity in several ways. Air, water and soil pollution has a direct adverse impact on the health of plants and animals which come in contact with environmental pollution. Industrial impacts mentioned above, such as global warming, ozone layer depletion, marine pollution etc. also have devastating effects on biodiversity.

The toxins manufactured and released by industries often get accumulated in the bodies of some organisms and gradually increase in concentration (a phenomenon known as biomagnification) thereby resulting in the death of all affected organisms.

It is this very phenomenon which has led to the local extinction of vultures from the National Capital Territory of Delhi (Fig 4). The vultures fed on carcasses of cattle which were injected with an industrially produced painkiller drug called diclofenac.



Figure 4. Preserved specimen of the last two vultures in Delhi at the National Museum of Natural History, New Delhi.

(Source: <http://delhigreens.com/2009/01/01/why-vultures-matter-part-i> Accessed on 20/03/2015 at 09.00 am)

Diclofenac was safe for cattle but when vulture fed on dead cattle who had this drug in their body, diclofenac proved to be lethal for the vulture population. It caused local extinction of this bird in areas where diclofenac was widely used. We will study more about the impact of industrial pollution on biodiversity later in this Chapter.

1.2 Global Warming

Planet Earth is the only known planet which supports life. This is largely because the Earth's temperature is neither too hot nor too cold which makes life, as we know it, possible to exist on the planet. Different parts of Planet Earth have different average surface temperature ranging from well below 0°C at the Poles to as high as 56.7 °C in the deserts. This temperature variation ensures the circulation of winds, movement of water through the hydrological cycle and in determining and controlling local, regional and global climate.

The average global surface temperature of the Earth has been consistently increasing since the industrial revolution (Fig 5). As of 2014, the average global surface temperature has risen by 0.68°C (NASA, 2015a). This may not seem much, but is enough to accelerate the melting of polar ice-caps, cause increase in sea-level and lead to climate change.

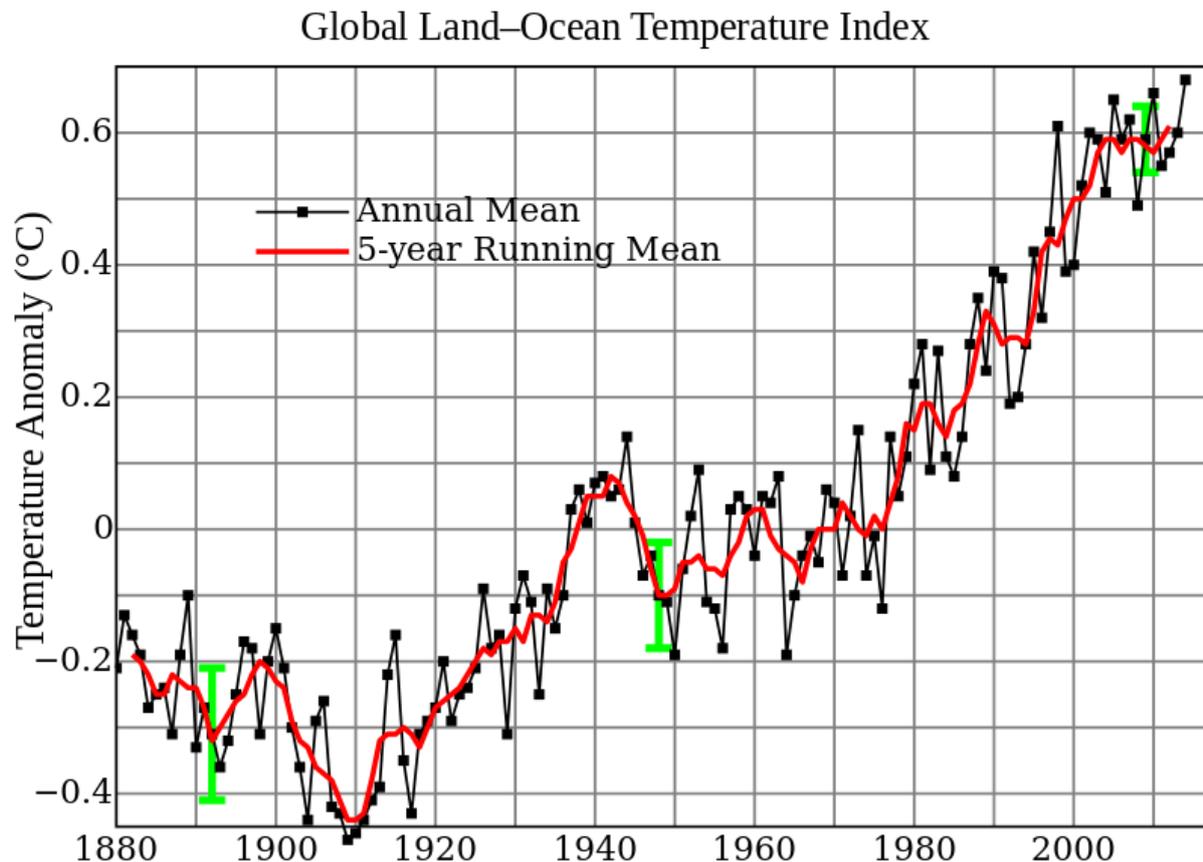


Figure 5. The average global surface temperature change from 1880 to 2014. Black line is the annual average and the red line is the 5-year running average. Green bars show uncertainty in data. Note the red line which clearly shows that there is an increase in average global surface temperature by almost 0.6°C in the last few years. (Source: https://commons.wikimedia.org/wiki/File:Global_Temperature_Anomaly.svg Accessed on 20/03/2015 at 09.00 am)

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Further increase in the average global surface temperature, which is already taking place, will only disturb the global climate system and cause unprecedented floods and severe droughts in different parts of the world simultaneously.

Consequently, the ten warmest years since 1880 have occurred in the last decade and 2014 was the warmest year ever recorded (NASA, 2015b). Data from the ongoing year (2015) suggests that this year may well be warmer than 2014. This is indicative of the continuous global warming trend being faced by our civilization today.

Web Resource: <http://newsroom.unfccc.int>

The United Nations Framework Convention on Climate Change (UNFCCC) provides up to date information about climate change and climate action by governments, companies, cities, the UN and civil society around the globe.

Before we proceed, it is important to understand as to how the Earth maintains its temperature. And why is the global temperature rising since the industrial revolution thereby altering the global climate system. This understanding is important for preventing further global warming and protecting our civilization.

Greenhouse Effect

Planet Earth is surrounded by a gaseous envelope which is known as the Earth's atmosphere. The atmosphere of the Earth traps the heat from reflection of the sun's rays after hitting the surface of the Earth. This trapping and re-radiation of heat from the sun's radiations after they have reflected from Earth's surface by some gases present in the Earth's atmosphere is known as *greenhouse effect* (Fig. 6).

The gases which are responsible for the aforementioned greenhouse effect are known as greenhouse gases (GHGs). Carbon dioxide, water vapours and methane are some examples of GHGs.

It is important to note here that GHGs are very essential for supporting life on Earth. This is because without these GHGs, the Earth will become a very cold and perhaps uninhabited planet. In fact, the presence of GHGs and the greenhouse effect phenomenon is so necessary that the latter is sometimes also known as the *atmospheric effect*.

Interestingly, it is this same greenhouse effect which is now causing global warming and subsequent climate change. An obvious question that needs to be asked here is that if greenhouse effect is a normal atmospheric phenomenon then why and how is it associated with global warming?

The answer is fairly simple. Greenhouse gases in the atmosphere are responsible for keeping the Earth warm and inhabitable. They do this by trapping heat from the sun's radiation after the sun's rays have reflected from the Earth's surface.

Since each unit of GHG has some potential of warming the Earth's atmosphere, the more GHGs we have in our atmosphere, the warmer it will become.

Now, a major component of industrial pollution is the release of GHGs which are released through the burning of coal and other fossil fuels on a large-scale. This addition of GHGs like carbon dioxide, methane etc. into the atmosphere as industrial pollution is what has enhanced the warming of the planet. And this increased warming of the planet is what is known as *global warming*.

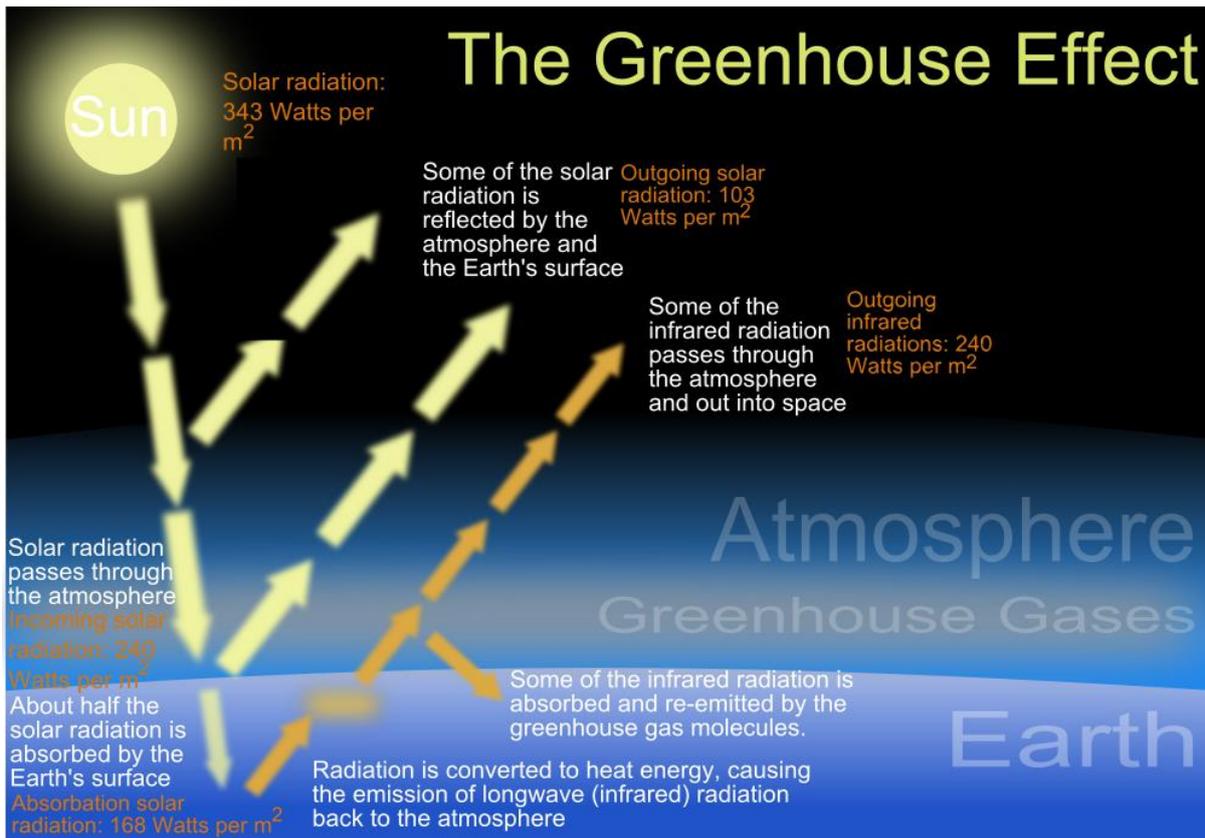


Figure 6. Diagram explaining the greenhouse effect.

(Source: https://commons.wikimedia.org/wiki/File:The_green_house_effect.svg
Accessed on 20/03/2015 at 09.00 am)

Global warming can thus be defined as the increase in the average global surface temperature due to the addition of air pollutants such as carbon dioxide, methane, nitrous oxide etc. which are also greenhouse gases.

These air pollutants are emitted from the burning of fossil fuels (coal and petroleum) which are extracted from deep within the Earth's crust.

Causes of Global Warming

Energy is the driving force behind the functioning and growth of the industrial sector. While there are many ways of generating energy, most of the global energy demand is presently being met by burning of fossil fuels (coal, petroleum and natural gas). Consequently, the single most factor responsible for causing global warming is the burning of fossil fuels for generating energy and for other related purposes.

Fossil fuels are fuels which contain high percentage of carbon and are formed by the anaerobic decomposition of buried dead organisms over millions of years. Fossil fuels are mined from deep within the Earth's surface. Due to increasing population and the ever-increasing industrial demand for energy, our society is mining fossil fuels much faster than this resource can be replenished.

Due to the large-scale mining and extraction of fossil fuels, human society is simply removing GHGs stored deep in the Earth's crust and is releasing it back into the atmosphere.

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Burning of fossil fuels like coal and petroleum releases billions of tonnes of carbon dioxide every year (Fig 7). Carbon dioxide is one of the principal GHGs. Although it is also emitted from natural sources like volcanic eruptions and respiration, anthropogenic emission of carbon dioxide through burning of fossil fuels is now accepted to be the chief cause of global warming.



Figure 7. Smoke (largely carbon dioxide and other GHGs) being emitted from a coal based thermal power plant.

(Source: <https://commons.wikimedia.org/wiki/File:Grangemouth04nov06.jpg> Accessed on 20/03/2015 at 09.00 am)

The evidence of the above is well articulated in the following sentence. The carbon dioxide concentration in the Earth's atmosphere has risen from 280 parts per million (ppm) in pre-industrial period (~1800) to above 400 ppm in the present day (Singh, 2014).

Thus, carbon dioxide is a quantitative pollutant. At normal concentration, it is required by us for keeping the planet warm. At the same time, an abnormal rise in its concentration in the atmosphere leads to enhanced warming, or global warming. It can therefore be concluded with considerable certainty that the main cause of global warming is the anthropogenic (man-made) emissions of GHGs due to the burning of fossil fuels by the industrial sector.

Unfortunately, despite this high contribution of fossil fuels to global warming, it continues to be our primary source of commercial energy.

Global Warming Potential

Different GHGs have different potentials to absorb the sun's radiations and warm the atmosphere of the planet. For addressing the issue of global warming, it is important that we know the global warming potential of different gases. Therefore, a concept of Global Warming Potential (GWP) has been developed, which is defined as the measure of how much radiation energy will be absorbed by one tonne emissions of a gas, relative to the absorption of radiation energy by one tonne of carbon dioxide.

Since carbon dioxide is the gas which has been used as a reference, its GWP is 1. The GWP of methane gas is approximately 30. This means that methane gas has 30 times more potential of causing global warming than the same amount of carbon dioxide gas. Likewise, the GWP of Nitrous Oxide is almost 300 while that of Chlorofluorocarbons (CFCs) can be in thousands or tens of thousands. CFCs (which also cause ozone layer depletion) are therefore sometimes also referred to as high-GWP gases.

Impacts of Global Warming

Global warming is leading to an increase in the global average surface temperature of the Earth. This is having several adverse impacts which are now being faced as threats to the life and property of our civilization. Some of these threats posed by global warming are enumerated below.

1. Melting of Polar Ice-caps

An increase in the global surface temperature is leading to the enhanced melting of the polar ice-caps. This melting of the polar ice-caps is leading to an increase in sea-level and is also changing the polar landscape thereby affecting the animals such as polar bears, seals etc. who live in and around the poles. Melting of polar ice-caps is also altering the global climate in ways that we may not even understand in the present day.

2. Sea-level rise

Sea-level rise is a very real threat being faced by all coastal cities as well as small island nations. Scientific investigations have confirmed that the global sea-level is rising at an alarming rate in the present century after having remained stable for 2000 years (IPCC, 2007).

This implies that cities like Mumbai and Chennai, which inhabit millions of people, are now under the threat of being submerged under the sea. The reason for this sudden sea-level rise is (a) the melting of land-based polar ice and (b) thermal expansion of oceans due to global warming (IPCC, 2007).

3. Glacial retreat

Glaciers around the world are now shrinking under the effect of global warming. This is concerning since glaciers are the source of rivers like River Ganga, which feed and quench the thirst of millions of people.

The shrinking of glaciers implies a reduction in the water flow of the rivers which originate from these glaciers. This will subsequently result in water shortage and will adversely affect agriculture productivity as well as drinking water supply of millions of people.

4. Interference with agricultural production and food security

An increase in carbon dioxide concentration, the pre-cursor of global warming, has the potential for increasing the yield of food crops. However, global warming itself will limit the production of food crops due to changes in the climate pattern.

Global warming is predicted to result in floods and droughts and reduction in the availability of water for irrigation as discussed above. Thus, global warming is already causing great interference with agricultural production and will only threaten our food security further in the near future.

5. Spread of diseases to newer areas

The changes in the weather pattern due to global warming will make some areas receive more rainfall and become wetter than normal. There is thus a huge concern that this will promote the spread of vector borne diseases (e.g. malaria, dengue, plague, and disease caused by viruses) to these newer areas.

To explain this further, if an area presently receives very little or no rainfall, it will naturally have very few, if any, cases of malaria (Odongo-Aginya et al., 2005). This is because malaria is spread by the mosquito vector and the latter requires puddles of water to lay eggs and increase their population.

However, due to global warming and resultant climate change, many parts of the world are now receiving excessive rainfall than normal. There are also some parts of the world where the rainy season has been extended by several weeks. This allows for the malaria and dengue causing mosquitoes to flourish and survive for longer periods of time in these areas and continue to spread the disease for extended duration.

6. Acidification of oceans

There is a constant exchange of gases between the atmosphere and the seas and oceans through the ocean/ sea surface. Thus, higher concentration of carbon dioxide in the air implies greater dissolution of carbon dioxide in the seas and oceans. The excess dissolved carbon dioxide in the water reacts with water molecules to form carbonic acid.

This process of increased addition of carbon dioxide in oceans and its reaction to form carbonic acid is leading to the acidification of oceans. Ocean acidification is a grave threat for marine organisms and can destabilize marine food chains and ecosystems. It also affects the metabolic functioning of both big and small sea animals.

7. Climate change

Climate change is a phenomenon which has now become almost synonymous with global warming. As opposed to weather, climate can be understood as the long-term statistical descriptions of temperature, humidity, precipitation, atmospheric pressure and winds or combinations of elements such as weather types for any region or for the planet as a whole. Climate change is therefore the change in the climate of a region (or the planet as a whole) which deviates from the normal weather patterns found in that region.

Global warming is increasing the average global surface temperature and is also affecting precipitation and humidity in different parts of the planet. Wind flow is also affected by global warming due to the temperature factor, thereby affecting weather phenomena such as monsoons. Thus, global warming is responsible for the long-term changes in the temperature, rainfall, wind flow etc. of different parts of the planet, and also of the planet as a whole. Global warming is therefore the precursor to climate change.

8. Extinction of species

Global warming is changing the climatic conditions and is altering weather patterns. Due to this many species of plants and animals, who are adapted to their native environment, are now facing the challenge of adapting to the rapidly changing environment. Not all plants and animals have the same ability to adapt to their changing environment and those species that are unable to adapt are rapidly becoming endangered or extinct.

Global warming also leads to local flooding, droughts and untimely rain events all of which are further threatening the survivability of plants and animals. Rapid climate change is thus leading to extinction of species and selective evolution of only those species which have the ability to adapt more swiftly.

Web Resource: <http://www.ipcc.ch>

The Nobel Prize winning Inter-Governmental Panel on Climate Change (IPCC) carries out regular assessments of the impact of climate change on human civilization and on the planet.

1.3 Biological Diversity (Biodiversity)

The sum total of all the variety and variability of living organisms and the complex ecosystems in which they exist is known as biological diversity, or biodiversity, of Planet Earth. Biodiversity exists at three levels, viz. i) genetic biodiversity, ii) species biodiversity and iii) ecosystem biodiversity.

All the different types of plants, animals and microbes constitute the species biodiversity. The different types of ecosystems (e.g. desert, aquatic, forest etc.) in which different species live and are adapted constitute ecosystem biodiversity. The genetic variation within each species (e.g. different hair colour of human beings, different breeds of dogs, etc.) constitutes the genetic biodiversity.

Biodiversity and its Importance

Biodiversity is important for a number of reasons. All our basic daily needs such as food, water, clothing and shelter are obtained directly from biodiversity. It is because of a healthy biodiversity that we can be assured of clean air, fresh water, food security and all the other benefits of Nature.

However, industrial growth and pollution has had an adverse impact on all the three levels of biodiversity. Industrial pollution is also responsible for the loss of biodiversity in many parts of the world.

One can argue that our civilization depends only on some plants and animals (e.g. wheat, rice, maize, poultry, cotton etc.) for meeting our daily needs. So why should we then protect all the species of plants and animals. After all, the total known species biodiversity of the world is well above 17,00,000! Why shouldn't we then simply use our resources for protecting only those few hundred species on whom we directly depend?

The answer to the above is fairly simple. The few hundred species on whom we depend for our survival, depend on another few hundred species for their survival. Further, the latter few hundred species depend on another few hundred or thousands of other species for their survival. Thus, no species on the planet is standalone and every species depends on many other species for its growth and survival.

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Honey bees and butterflies may not seem of much consequence to many. However, they are so important that extinction of honey bees and butterflies will lead to a complete reduction in our food production. This is because bees and butterflies provide the extremely useful and irreplaceable service of pollinating the plants. Without pollination, most of our crops will stop producing seeds and fruits that we need for meeting our daily food requirements.

At the same time, human growth and survival depends on different types of biodiversity in ways that we may not even realize. For example, we may think that tigers need to be protected mainly for ethical reasons or for national pride. But a healthy tiger population ensures a functioning forest ecosystem. And healthy forests bring rain, prevent climate change and protect genetic diversity of all the other animals and plants living in that forest (Fig 8). Tigers also support livelihood of people by promoting tourism and through securing nature's bounty by ensuring a healthy forest.

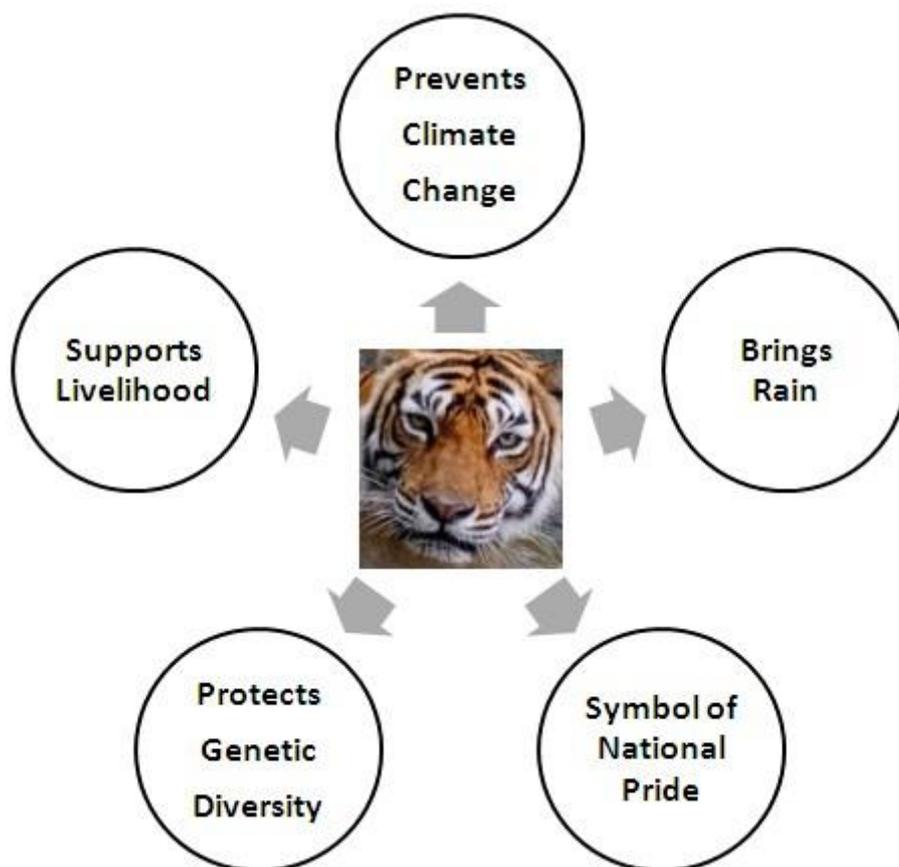


Figure 8. The importance of tigers to human society.

(Source: <http://delhigreens.com/2009/07/23/top-five-reasons-for-why-must-you-act-to-save-the-tiger> Accessed on 20/03/2015 at 09.00 am)

The importance of biodiversity can also be understood by realizing that cure to many human diseases has been found only by exploring the biodiversity. To cite just one example, antibiotics (which save millions of lives today) were first discovered from a fungus called *Penicillium notatum* by Sir Alexander Fleming in 1928.

If this fungus species had gotten extinct before the antibiotic could be discovered, all of us would be at the risk of losing our lives because of even a minor cut or bruise in our body. Similarly, cure to deadly diseases like cancer, AIDS etc. may be hidden in the

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biodiversity reservoir. It is therefore important that we protect biodiversity in totality for the present and the future generations.

Threats to Biodiversity

The global biodiversity today is under threat due to many factors. Most of these factors are directly or indirectly linked to the industrial sector. Some prominent threats to biodiversity are enumerated below.

1. Over-exploitation of Natural Resources

Natural resources are the raw material for the industrial sector. Mining of minerals such as iron, aluminium, bauxite etc. and pressurised organic decompositions like coal and petroleum from deep within the Earth is a pre-requisite for the working of the industrial sector.

Because the industrial sector depends on these natural resources, permission to extract these raw materials is given to them. However, with increasing demand from the industrial sector and more and more industries being set up, we are now extracting natural resources at a very high rate.

This over-exploitation of natural resources is a big threat to biodiversity since minerals, coal and petroleum are buried deep in the Earth's crust under forested areas. Removing them often requires the removal of forests and causes massive disturbance to the wildlife.

2. Habitat Degradation and Loss of Habitat

The different types of forests are the habitat of plants and wild animals. The destruction of forests due to mining activities, construction of big dams and cutting of forests for obtaining raw materials results in loss of habitat for the biodiversity. This directly results in the reduction of biodiversity and is therefore a significant threat to biodiversity.

Sometimes, industrial development requires the construction of roads or railway tracks through forests. Once the road or the railway track is laid down, it divides the forest into two (or sometimes more) fragments. Wild animals can no longer roam freely in the forest and are faced with the threat of roadkill. This phenomenon of fragmentation of the forest is known as *habitat fragmentation*.

3. Industrial Pollution

The industrial sector often manufacture non-biodegradable pollutants or substances which do not degrade in nature. These substances gradually enter the food chain and start accumulating inside plants and animals as toxins. Eventually, those animals which are higher up in the food chain accumulate much more of this toxin in their body and start dying. This phenomenon of increase of pollutant/ toxin concentration in the food chain at every trophic level is known as *biomagnification*. Figure 9 illustrates the biomagnification phenomenon in the following food chain:

I. Grass → II. Rat → III. Snake → IV. Hawk

If a small amount of toxic pesticide such as DDT (represented in Fig.8 as '+' sign) enters the soil, it will be absorbed and accumulated by the grasses in their plant body. The concentration may not be enough to damage individual grass plants and each grass plant will remain alive but have DDT accumulated in its body (since DDT is non-biodegradable). Parts of this grass plant will be eaten by rats, and each rat will feed on many grass plants. Therefore, the concentration of DDT in each rat will be more than the concentration of DDT in each grass plant.

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Further, each snake will eat many rats with DDT in their body. So the concentration of DDT in each snake will be more than what it is in each rat's body. Finally, each hawk (the highest trophic level in this food chain) will feed on many such snakes and so the concentration of DDT in each hawk's body will be much more than what it is each snake's body and much more than what it is in each grass plant's body. The concentration of DDT in the hawk's body could be so much that it could kill the hawk or interfere in its body functioning.

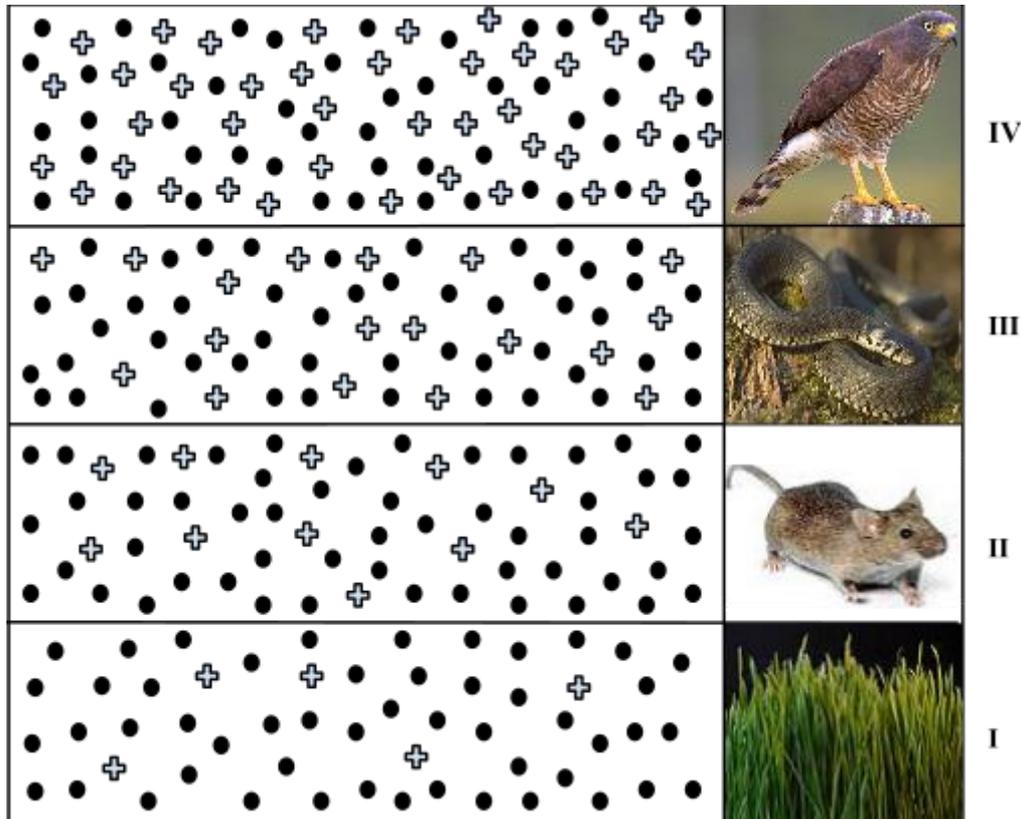


Figure 9. An illustration of the biomagnification phenomenon taking place in a terrestrial food chain.

(Source: <https://commons.wikimedia.org/wiki/File:Biomagnification.svg> Accessed on 20/03/2015 at 09.00 am)

Thus, industrial release of pollutants as waste products and non-biodegradable toxins (like pesticides) as finished products interferes with the food chain and leads to reduction in biodiversity and local and global extinction of species.

Another very significant impact of industrial pollution on biodiversity is known as *industrial melanism*. Before the industrial revolution took place in Europe, there were mainly light-coloured trees and the dominant moths found had light coloured wing patterns. However, with the advent of industrial revolution, the trees got covered with dark soot which was released as a result of large-scale burning of coal. After the industrial revolution took place, the population of the moths with light coloured wing patterns reduced. The dominant moths were now found to be those with dark coloured wing patterns.

This happened because earlier the light coloured moths could camouflage and hide themselves in the light coloured trees and escape predators such as birds. However, when the trees turned black with soot, their camouflage stopped working and they became easy prey to birds.

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On the other hand, the dark-winged moths could now camouflage and hide themselves in the trees and as a result their population became larger in number. This genetic darkening of species as a result of industrial pollution has been referred to as *industrial melanism*. Industrial melanism goes on to show how industrial pollution alters the normal functioning of the ecosystem in a grave manner.

4. Global Warming and Climate Change

Global warming is modifying the environment of species at an unnatural rate. It has therefore become a big threat to biodiversity and to those plants and animals which may not be able to adapt quickly to these changes. Climate change is causing a similar threat to biodiversity, by altering the onset and duration of seasons and weather patterns in the long-term.

5. Poaching

The illegal hunting of wild animals such as tigers, rhinoceros, elephants etc., mainly for their body parts is known as poaching. Tigers are killed for their bones and teeth, rhinoceros is killed for its horn and the elephant is killed for ivory.

Poaching results in reduction in the number of those wild animals which are needed for maintaining a healthy habitat for all the other species who share their habitat with these wild animals. Poaching is thus a very concerning threat to biodiversity and must be prevented through better policing of our sanctuaries, national parks and biosphere reserves.

1.4 Industrial Pollution: Monitoring and Management

Industrial pollution has become a major environmental challenge faced by our civilization today. Industrial pollution has led to many environmental problems such as global warming, climate change and biodiversity loss.

Environmental management and monitoring of the industrial sector for preventing industrial pollution is therefore an important measure that needs to be taken by every nation.

The first global conference which took place in this direction was the United Nations Conference on Human Environment which was held in Stockholm in 1972. It mandated that "The protection and improvement of the human environment is a major issue which affects the well-being of peoples and economic development throughout the world; it is the urgent desire of the peoples of the whole world and the duty of all Governments" (UNEP, 2015).

Taking cue from the Stockholm Conference, the Government of India set up the Central Pollution Control Board (CPCB) in the year 1974 as the premier pollution monitoring and controlling agency in India. The CPCB works with the help of a state level pollution control boards. Monitoring of industrial pollution is a key agenda of the CPCB.

The CPCB also sets guidelines and industry specific environmental quality standards so that industries are required to check and control their polluting activities. For example, the maximum permissible sound pressure level for new diesel generator (DG) sets (capacity up to 1000 Kilo Volt Amperes) manufactured on or after 1 January, 2005 is 75 dBat 1 metre from the enclosure surface (CPCB, 2008). If any industry or factor is found to have a DG set emitting noise higher than this value, the respective industry or factory can be penalized by the CPCB.

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An important achievement of the CPCB in monitoring and controlling industrial pollution is the development of a Comprehensive Environmental Pollution Index (CEPI). The CEPI score is a number which is given to each industrial cluster in the country after assessing the various dimensions of environment including air, water and land quality of that area.

Based on nationwide assessment of industrial clusters using CEPI, the CPCB has identified a total of 43 Critically Polluted Industrial Areas (CPCB ENVIS, 2015). The Najafgarh drain basin area in Delhi, Faridabad NOIDA, Panipat, Ludhiana, Mandi Gobind Garh, Jodhpur, Bhiwadi, Ghaziabad, Kanpur and Agra are some of these Critically Polluted Areas located in North India. The environmental pollution in these areas is monitored very rigorously and it is not very easy to set up new industries in these already critically polluted areas.

Due to the existence of environmental quality standards and monitoring by the CPCB, the industrial sector in India has adopted many measures to reduce emission of pollutants. Industries releasing waste water install effluent treatment plants (ETPs) to remove pollutants from the waste water before it is released in the nearby river or water body. Factories producing smoke install tall chimneys or stacks with filters for collecting harmful particles. Industries are also careful about dumping their solid waste such as debris, electronic items, batteries etc. since there are strict rules in place for the safe disposal of such items.

Despite having strong environmental policies and laws in India, the status of environment is increasingly getting worse. While the rapidly increasing population can be a reason for the increasing pollution, it is also often pointed out by the civil society that while India has some of the best environmental laws, there is very little implementation of these laws. There is thus a need for more rigorous monitoring of industrial pollution and better implementation of the laws made for controlling environmental pollution.

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Glossary

Acid Rain:	The reaction of sulphur dioxide and nitrous oxide pollutants with rain water to form acid in the upper atmosphere and the falling of this rain water on the surface of the Earth is known as acid rain.
Biodiversity:	The sum total of all the variety and variability of living organisms and the complex ecosystems in which they exist is known as biological diversity, or biodiversity, of Planet Earth.
Biomagnification:	This phenomenon of gradual increase of pollutant/ toxin concentration at every trophic level in the food chain is known as <i>biomagnification</i> .
Climate Change:	A prominent and consistent change in the climate of a region (or the planet as a whole) which deviates from the normal long-term weather patterns found in that region.
Eutrophication:	The abnormal growth of green plants or algal blooms caused in water bodies like ponds and lakes as a result of washing away of fertilizers from nearby agricultural fields and entering these water bodies as rainfall run-off is known as eutrophication.
Fossil Fuels:	Highly compressed organic materials like coal and petroleum which are formed from the remains of living organisms buried in the Earth's crust millions of years ago and have high calorific value.
Global Warming Potential:	The measure of how much radiation energy will be absorbed by one tonne emissions of a gas, relative to the absorption of radiation energy by one tonne of carbon dioxide.
Greenhouse Effect:	The trapping and re-radiation of heat from the sun's radiations after they have reflected from Earth's surface by some gases present in the Earth's atmosphere is known as greenhouse effect.
Industrial Melanism:	This genetic darkening of species as a result of industrial pollution is referred to as industrial Melanism.
Poaching:	The illegal hunting of wild animals such as tigers, rhinoceros and elephants mainly for obtaining their body parts is known as poaching.

Multiple-choice Questions

Question Number	Type of question
1	MCQ

Question

Minamata disease is caused by eating fish which has bio-accumulated which heavy metal in its body?

- (a) Lead
- (b) Mercury
- (c) Iron
- (d) Arsenic

Correct Answer / Option(s)	(b) Mercury
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Justification/ Feedback for the correct answer

Minamata disease was first found to occur in Minamata Bay Area in Japan as a result of discharge of mercury pollution in the Bay by a chemical manufacturing company called Chisso Corporation. People living around the Minamata Bay, who consumed the fish caught from the Bay, suffered from Minamata disease.

Question Number	Type of question
2	MCQ

Question

Which poisonous gas was accidentally released from the Union Carbide factory in the Bhopal Gas Tragedy of 1984?

- (a) Ozone
- (b) Chlorine Gas
- (c) Methyl Isocyanate
- (d) Methyl Isocyanide

Correct Answer / Option(s)	(c) Methyl Isocyanate
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Justification/ Feedback for the correct answer

The Bhopal Gas Tragedy occurred on the night of 2nd December, 1984 in Bhopal, Madhya Pradesh by the accidental release of Methyl Isocyanate from a chemical manufacturing plant of Union Carbide (now Dow Chemicals).

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Question Number	Type of question
3	MCQ

Question

Which among the following greenhouse gases has the highest Global Warming Potential?

- (a) Carbon dioxide
- (b) Methane
- (c) Nitrous Dioxide
- (d) Chlorofluorocarbons (CFCs)

Correct Answer / Option(s)	(d) Chlorofluorocarbons (CFCs)
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Justification/ Feedback for the correct answer

Chlorofluorocarbons have very high Global Warming Potential running into thousands and tens of thousands because of which they are also known as high-GWP Gases.

Question Number	Type of question
4	MCQ

Question

The carbon dioxide concentration in the Earth's atmosphere in 2015 is:

- (a) Below 300 parts per million (ppm)
- (b) Below 350 parts per million (ppm)
- (c) Above 400 parts per million (ppm)
- (d) Above 450 parts per million (ppm)

Correct Answer / Option(s)	(c) Above 400 parts per million (ppm)
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Justification/ Feedback for the correct answer

As of 2015, the carbon dioxide concentration has risen to above 400 parts per million (ppm) which is the highest since present day monitoring of atmospheric greenhouse gases has begun.

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Question Number	Type of question
5	MCQ

Question

Honey bees are very important to human civilization mainly because:

- (a) They give us honey
- (b) They give us wax
- (c) They perform pollination
- (d) They make bee hives

Correct Answer / Option(s)

(c) They perform pollination

Justification/ Feedback for the correct answer

The most important service provided by honey bees is that of pollination. Without pollination of our agricultural crops, fruits and vegetables, our food production will be severely affected.

Short-answer Questions

- Q. 1 What is industrial pollution? Why has industrial pollution become one of the most important environmental challenge in the present day?
- Q. 2 Discuss the role of industrial pollution in causing global warming and climate change.
- Q. 3 What are the impacts of global warming on human civilization?
- Q. 4 Define biodiversity. What is it important to protect the biodiversity of the planet in totality?
- Q. 5 Enlist some prominent threats to biodiversity. How does industrial pollution impact biodiversity?