ENVIRONMENTAL GEOSCIENCES

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Lecture-50

Fossils Fuels

Welcome to the SWAYAM NPTEL course on environmental geosciences. Today we will start the module ten. In module ten we will discuss about the fossil fuels and conservation of non-renewable energy. Today I will discuss the lecture one that is fossil fuel. Important concepts of lecture one are introduction of fuels, introduction to fossil fuels,

formation of fossil fuels, classification of fossil fuels, calorific value of fuels, world energy consumption by fossil fuels type and environmental impact. Now we will discuss the introduction of fuels. Now we will discuss the fuels. A fuel can be described as any material that can undergo exothermic structural change. Often this change is chemical in nature such as through combustion which requires an oxidant. Occasionally the change may occur through exothermic decomposition such as in the case of some propellants. The chemical potential energy of a fuel released through combustion should be viewed as, in principle, much more versatile and valuable than its equivalent in the form of heat energy.

Much of the widely used fuels are organic in nature which contain relatively versatile carbon atoms. There are some inorganic fuels such as hydrogen, ammonia, H_2S and metals that are much less widely available in comparison with organic fuels. They constitute at present only a small fraction of the energy extracted from fuels in general. Moreover, common fuels may be naturally occurring in origin, such as petroleum, natural gas and coal, or manufactured, such as alcohols and hydrogen. Most of the fuels available to us are of fossil origin.

They were formed primarily from living matter in geological times. Historically, their relatively plentiful reserves, low cost, convenience of use, high energy content and the lack of environmental concerns during the past made the fossil fuels very attractive. They were used extensively over the past decades. However, this situation has been changing in recent years and attention is increasingly being given by all to the conservation and

optimum use of these irreplaceable energy resources. They constitute our non-renewable natural resources legacy.

Fuels can be broadly classified in a variety of ways, such as on the basis of their properties or field of application. Some of the most common classifications depend on whether they are solid, liquid, or gas. Organic or non-organic, fossil or non-fossil, conventional or alternative, mineral fuels or biofuels of low heating value, medium heating value or high heating value or next is the natural or manufactured. Now let us understand the fossil fuels. Fossil fuels are naturally occurring substances in earth made up from the remains of ancient plants and animals over the geological time.

Fossil fuels are fuels formed by natural resources, such as anaerobic decomposition of buried dead organisms. Fossil fuels are of great importance because they can be burned, producing significant amounts of energy. Fossil fuels consist largely of hydrocarbons, which are complex chains of hydrogen and carbonate atoms. They are extracted from the earth crust, The formation of fossil fuels.

Very special circumstances were required for the formation of fossil fuels that are so important to our modern life. Coal, oil and gas are organic materials that is they are plant and animal remains composed mostly of reduced carbon. As plant life evolved some three billion years ago, a great deal of organic material was formed, most of which was oxidized relatively soon and turned back to carbon dioxide in the atmosphere, which is not an energy source but is available for new plant growth. Some very small part of this organic material found its way to anaerobic basins such as deep lakes or marine areas for oil and gas and hence accumulated as various deposits. Chemically natural gases that is methane has four molecules of hydrogen per molecule of carbon.

Oil has about equal amounts and coal is mostly carbon, although with small amounts of hydrogen and sulphur and trace amounts of many elements, including troublesome mercury and uranium. Thus, there is a progressive increase in CO_2 per unit of energy delivered from natural gas to oil to coal, with coal releasing almost double the CO_2 per heat unit relative to gas. The creation of exploitable oil and gas fields has been quite rare in the geologic past. It happened mostly some ninety and hundred one fifty million years ago when Earth was very warm and in very special and limited environments.

Here you can see the usual formation of oil and gas. The first diagram, it tells how a deep trench is generated in the earth from crustal movements. Marine life including phytoplankton and zooplankton grow in the trench and fall to the bottom. If the trench is

deep and warm enough, anaerobic conditions exist and the organic material accumulates for many millions of years. In the second diagram B, you can see if this is followed by heavy rains, sediments fall onto the organic material, further protecting it from oxidation and pressure cooking it into shorter length carbon chains.

An ideal depth for this is about three thousand to four thousand meter. And in the last diagram that is C, the light oil and gas move upward through the earth and most is lost to the atmosphere. Some small part is trapped by impermeable geological structures such as anticlines of sandstone and remains as oil and gas deposits which can then be exploited. The time required to turn the organic source material into oil and gas is extremely long and requires the organic material being buried at just the right depth that is about three thousand meter or two miles and temperature about hundred degree celcius to pressure cook the organic material into oil.

As a consequence, significant quantities of commercially exploitable oil and gas are found in only a relatively few regions of the Earth's surface. Coal formed in great freshwater swamps required for less stringent conditions for its production and is more common. Gas too is widely dispersed, but large reservoirs are relatively rare. On the other hand, gas is found widely at low concentrations associated with coal and in tight shales and sandstones. Exploitation of these diffused resources is becoming increasingly important as the large gas fields found earlier face serious depletion.

Whether or not these newer unconventional fields can maintain production at the present level for very long is unknown at this time. Now classification of fossil fuels. There are three major groups of fossil fuels, that is coal, oil, and natural gas, which were formed over millions of years. The age at which they were formed is described as the Carboniferous Period, which is named after the carbon and the main constituent, which is named after the carbon that is the main constituent of fossil fuels. It is accepted that as living matter died, it sank to the bottom of swamps, lakes and seas, which then formed spongy material after being covered by sand and the mineral matter to turn in time into a rock type described as sedimentary.

With the accumulation of more rocky material and the combined action of temperature, pressure, catalyst and bacteria over a long time, coal, oil and natural gas were formed. The first fossil fuel that is coal. Coal is a combustible black or brownish black sedimentary rock formed as a strata called coal seams. Coal is readily combustible rock consisting of more than fifty percent by weight and more than seventy percent by volume

of carbonaceous materials. Coal is formed when dead plant matter decays into peat and is converted into coal by the heat and pressure of the deep burial over millions of years. Types of coal, the main types of coal are lignite, bituminous and anthracite. These types are classified based on the amount of carbon, oxygen and hydrogen in the coal.

The first type is the lignite, the youngest form of coal, soft and brownish black in color. It has a high moisture content and low carbon content, used in power generation as a fuel in some industrial processes. Bituminous coal, it is also known as black coal, contains a tar-like substance called bitumen or asphalt, the most widely available and used coal. Next is the anthracite also known as hard coal and black coal. Hard, compact and glossy.

Anthracite has the highest carbon content and the highest energy density of all types of coal. It is used primarily for residential and commercial space heating. Now coal transformation. Peat is altered to lignite, lignite is altered to sub-bituminous, sub-bituminous coal is altered to bituminous coal, and bituminous coal is altered to anthracite coal. Positives and negatives of the coal, you can see the positives,

Impact, it heats our homes, it is burned in power plants to produce electricity, and the US contains one quarter of the world's coal reserves, which could provide more energy potential than all the known recoverable reserves of oil. The negative impact you can see coal production requires large quantity of water which affects the habitats of both aquatic and land-based wildlife as well as people who use these water resources. The process of burning coal for energy produces greenhouse, the process of burning coal for energy produces greenhouse gases and other harmful pollutants including carbon dioxide mercury compound sulphur dioxide and nitrogen oxides. Now coal uses. Coal is very commonly used today to produce electricity.

Coal is also used in iron steel production, cement manufacturing, in the production of coal tar, home heating and any number of industrial applications that require heat. There we are using the coal. Next fossil fuel is the oil. It is also known as crude oil. It has been used for over four, five thousand years.

It has been used for over five thousand years. It is a non-renewable resource of energy that is used to generate electricity and power vehicles. Oil is a liquid fuel. composed of decayed organic matter that occurs naturally in the underground reservoirs. It is extracted subsurface reservoirs as crude oil and is sent to a refinery for separation into its various component fuels such as kerosene, diesel oil and aviation fuel. Oil Formation

Oil was formed from the remains of animal and plants that live millions of years ago in a marine environment before the dinosaurs. Oil was formed from plants called plankton. When the plankton dies, it sinks in the bottom of the sea and is buried under layers of sand and mud. When these layers are mixed, it turns into a hard rock but when bacteria eat the plankton, it turned into ooze and then into oil. Positive and negative impacts.

Positive, oil is an extremely powerful energy source when it is burned. No other fuel can move a vehicle at such a speed and for such a distance as a cup of petroleum can. It can also run day and night, providing a constant source of power, unlike solar and wind power, which are intermittent. The negatives Oil may contribute to global warming in its production and use by releasing carbon dioxide, a greenhouse gas. Whenever there is an oil spill, there is usually a massive environmental disaster. Evaporation and fumes also pollute the environment.

It is getting harder to find which is making it more expensive. Oil uses, when petroleum is refined, its various chemical parts are separated and some become gasoline, some lubricants, some asphalt and others the raw materials for the plastics and rubber and many more things. We use petroleum products to propel vehicles to heat buildings and to produce electricity. In the industrial sector, the petrochemical industry uses petroleum as a raw material to make products such as plastics, polyurethane, solvents, and hundreds of other intermediate and end-user goods. Now, fossil fuels, that is the natural gas.

Natural gas is a fossil fuel that forms from organic materials that have been subjected to heat and pressure over millions of years. Its primarily made up of methane but also contains other gases like butane and propane. You can see the volume percentage of different components as a typical composition of natural gas. We can see here that methane is greater than eighty five percent by volume that is CH_4 remaining as a higher content. It is also containing other gases like butane and propane as well.

Natural gas formation, the theory states natural gas is composed of remnants of decayed plant and animal matter that has been subjected to immense pressure under the earth crust over millions of years. A further way in which natural gas can be produced by microorganisms breaking down organic matter and producing methane. Natural gas is made up of a combination of gases which consist largely of methane with lesser amounts of ethane, propane and butane as well as nitrogen, carbon dioxide and traces of some other gases. Positive and negative impacts. We can see here, the positive impacts, the natural gas burns cleaner than other fossil fuels like coal and oil.

Natural gas is a reliable energy source, unlike electricity that can be affected by storms. Natural gas can help transition to a renewable energy economy. Negatives, the natural gas contributes to climate change when burned, releasing carbon dioxide and water vapor. The extraction and transportation of natural gas can cause air pollution and noise. The extraction of natural gas can require significant infrastructure development which can also contribute to carbon dioxide emissions.

If there is a leak, it may cause fire or explosion. The usage of natural gas. The natural gas is used to produce steel, glass, paper, clothing, brick, electricity and as essential raw material for many common products. Some products that use natural gas as a raw material are paints, fertilizers, plastics, antifreeze, dyes, photographic film, medicines and explosives. Calorific value of fuels.

When fuels are burnt, heat is produced. The amount of heat produced by different types of fuels on burning is expressed in the terms of calorific value. Calorific value of a fuel may be defined as the amount of heat produced on complete burning of one gram of fuel. SI unit of calorific value of fuels is kilojoule per gram. For example, when one gram of wood is burned completely, it produces seventeen kilo joules of heat.

Therefore, the caloric value of wood is seventy kilo joule per gram. In similar manner, when one gram of kerosene oil is burned completely, it produces forty eight kilo joules heat. So, the calorific value of kerosene oil is forty eight kilo joules per gram. The calorific value of different types of fuels are also given in the table. You can see here hydrogen one fifty kilo joule per gram, methane fifty five kilo joule per gram, LPG fifty kilo joule per gram, kerosene oil forty eight kilo joule per gram, charcoal thirty three kilo joule per gram and wood seventeen kilo joule per gram.

Significance of calorific value, it becomes clear from the earlier discussed table that different fuels have different calorific value, that is different fuels produce different amounts of heat on burning. The calorific value of fuels help us to decide that which fuel is good for us. This is done by comparing the calorific value of fuels with each other. Usually a fuel having higher calorific value is considered to be a good fuel. Hydrogen gas has the highest calorific value of one fifty kilo joule per gram among all the fuels.

So hydrogen gas is considered to be an extremely good fuel. However, hydrogen gas is not used as a fuel in homes and industries. The main reasons for this are hydrogen gas is highly combustible and it burns with explosion when lighted. The storage and

transportation of hydrogen gas from one place to another is very difficult. The cost of production of hydrogen gas is very high.

Methane and butane, almost all the fuels consist of atoms of hydrogen and carbon. Since the calorific value of fuels depends on the percentage of hydrogen present in them, so the fuels which have higher percentage of hydrogen will have higher calorific value as compared to those fuels which have lower percentage of hydrogen. The percentage of hydrogen present in methane is twenty five percent, whereas the percentage of hydrogen present in butane is seventeen percent. Due to this reason, methane has a higher calorific value as compared to butane. World energy consumption by fossil fuel types.

Fossil fuel energy is a finite resource. While there are still large supplies of coal, oil and natural gas, the demand is increasing as the amount of new supplies being found is decreasing. Worldwide energy use has been increasing and is projected to keep on increasing as shown in the graph, especially the demand for oil. Environmental impact. Fossil fuels are the largest greenhouse gas emitters in the world, contributing three-fourths of all carbon, methane and other greenhouse gas emissions.

Burning coal, petroleum and other fossil fuels at extremely high temperature is the primary means by which electricity is produced, but also leads to heavy concentration of pollutants in our air and water. The real problem is that the atmosphere already absorbs a ton of greenhouse gases naturally but is trapping up to twenty five percent more of the sun's radiation due to annual increases in the greenhouse gas emissions. Nitrogen oxides and sulfur dioxide combine with water, oxygen and other chemicals to form acidic pollutants which leads to smog and acid rains. Demarcation of natural habitats and pollution associated with fossil fuel extraction and combustion can lead to biodiversity loss. Now just I will summarize the lecture one.

I have discussed first about the introduction of fuels. A fuel can be described as any material that can undergo exothermic structural change. Often this change is chemical in nature, such as through combustion, which requires an oxidant. Then I have discussed the introduction and formation of fossil fuels. Fossil fuels are natural substances in earth made up from the remains of ancient plants and animals over time.

Classification of fossil fuel, the three major group of fossil fuel that is the coal, oil and natural gas. The fossil fuel coal, coal is a combustible, black or brownish black sedimentary rock formed as a rock strata called coal seams. The main types of coal are lignite, bituminous and anthracite. Fossil fuel oil, oil is a liquid fossil fuel composed of

decayed organic matter that occurs naturally in underground reservoirs. Next fossil fuel is the natural gas. Natural gas is a fossil fuel that is found from organic materials that have been subjected to heat and pressure over millions of years. And lastly I have discussed about the caloric value of fuels. Calorific value of a fuel may be defined as the amount of heat produced on complete burning of 1 gram of fuel.

SI unit of calorific value of fuels is kilojoule per gram. Thank you very much to all.