ENVIRONMENTAL GEOSCIENCES

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Lecture-4

Concept of Hydrosphere, Lithosphere and their Constituents

Welcome to the SWAYAM NPTEL course on Environmental Geosciences. We are continuing the module 1 which is about the introduction to the origin of the Earth already covered in the lecture 1. Then the internal structure of the Earth covered already in the lecture 2 and the concepts of atmosphere I have already covered in the lecture 3. So today we will cover this lecture 4 which is related to the hydrosphere, lithosphere and their constituents. In this lecture, the important concepts will be covered like hydrosphere, constituents of hydrosphere, lithosphere and constituents of lithosphere.

So we know that the earth's interior is made up of three important types of layer that is crust, mantle and core we have learnt already in the previous lectures. So this crust, total crust plus upper mantle constitute the lithosphere. Hydrosphere generally is a continuous layer of salt and fresh water covering the earth's surface in the form of oceans, seas, lakes, rivers, groundwater, ice and snow etc. Whatever else we are getting on the surface of the earth in terms of the layer of salt and fresh water, this is under the upper view of the hydrosphere. The world ocean which is a part of the hydrosphere covers approximately 71% of the earth's surface with an average depth of about 3800 meters.

The hydrosphere plays a crucial role in regulating the climate, supporting the marine life and cycling the nutrients on the Earth's surface. So this sphere is also very very important with compared to atmosphere and lithosphere for understanding the environmental geosciences. Now, if you will see the glimpse of the water resources on the Earth's surface, this is just a graphical distribution of the locations of water on the Earth. You can see here, there 97%, 97% of the, of, of the Earth's surface is covered by saline water, saline water and remaining 3% is only covered by fresh water. So this is about the Earth's water.

So generally we are getting 97% oceanic water and 3% fresh water in terms of surface water or groundwater. Now just it is the showing the details about the fresh water. If you

will see here this fresh water encompasses groundwater, 30.1%, ice caps and glaciers near about 68.7%, and others is only 0.9%. Now, this, if you will just see about the details about the others, you can see the surface water constitute near about the 0.3%. Lakes water constitute near about the 87 percent and the swamps you can get near about 11 percent and rivers which is a surface water is about 2 percent.

So in this way this graphical distribution shows how the water is distributed on the different different locations of our Earth's surface. So this is important because if you will see the importance of the hydrosphere it consists of all bodies of water whatever body different types of bodies of waters are remaining on the earth icebergs and water vapor in the atmosphere. So oceans contain 97 percent of water in the hydrosphere while rivers, lakes and other water bodies on land covers the detail on the Earth's surface. Underground water contains a small percentage of total water in the hydrosphere. Underground water which we are telling as a groundwater. It is a very, very small percentage of the total water.

So that's why we are getting the scarcity of the groundwater, potable water. It helps to maintain the hydrological cycle. This is one of the very, very important cycles. Hydrological cycle comprises of precipitation, evaporation, transpiration and surface runoff. So this hydrological cycle is also one of the important cycle within the hydrosphere.

Hydrosphere is a very good means of transport of water also and it plays a very important role in the Earth's climate. So this is about the importance of this hydrosphere. This hydrosphere is very very important for the survival of the living beings. Now, question is, how is the hydrosphere changing? Because we are getting scarcity of water at every places on the globe.

So here just some brief account is given how the hydrosphere is changing due to global warming. We are very familiar with the global warming and if you will see the impact of the global warming, the first impact is the increased evaporation and accelerated hydrological cycle i have told you hydrological cycle comprises of precipitation that is rainfall then the evaporation then transpiration evaporation means water loss from the open water surface on the earth surface say from lakes ponds rivers etc. And transpiration means water loss from the leaf of the plants which is just sending the water to the atmosphere by stomatal opening through a stomatal opening. So increased evaporation is very very important if the global warming will take place. Human

contribution is there definitely for generation of the greenhouse gases. And these greenhouse gases are warming the Earth's surface. This is leading to the increased evaporation of the surface water.

And once it is increasing, it is accelerating the hydrological cycle. So this is the first impact because of the global warming. Second impact we can see more water vapor in the atmosphere. So a warmer atmosphere can hold more water vapor which can lead to more extreme weather events evidence suggests that the global warming is already causing more extreme precipitation events. So this has been proved also by some evidences. Because of the increase of the greenhouse gases It is already causing more extreme precipitation events. So this is the second impact because of it more water vapor in the atmosphere.

Then third is the shifts in the precipitation pattern. So global warming is expected to cause shifts in the precipitation patterns, rainfall patterns with some areas becoming wetter and the other becomes drier. So some areas are getting more water and some areas are remaining with very very less amount of precipitation. So regions at high latitudes that is near to the northern hemisphere are likely to see more precipitation. Now so it, in hydrosphere we are seeing that shifts in precipitation pattern is also taking place because of the increase of the global warming.

Changes in types of precipitation. Precipitation may shift from snow to rain, especially in mountainous regions where generally snow falls. But we are seeing that in the mountainous regions also, because of the increase of these greenhouse gases or the impact of the global warming, the precipitation types have also shifted. That is from the snowfall to rainfall. This change could reduce mountain snowpack and affecting the timing and quantity of seasonal runoff.

Runoff is the water which is just flowing through the topography of the Earth's surface. So this change also we are noticing. Impact on snow-fed river system. Many rivers are remaining snow-fed. So here, rivers that depend on snow melt, for example, for Himalaya, will experience altered timing and volumes of, different different volumes of runoff.

So this will affect billions of people who rely on these rivers for water, for agricultural purposes and for industrial activities. So this is the another impact we are seeing in the hydrosphere because of the increase of the global warming. Now ocean warming and expansion. As the Earth warms, ocean water absorbs heat and expands. So, about half of the current sea level rise is due to thermal expansion of water.

So, this is the another facts because of this half of the current sea level rise is due to the thermal expansion of water. Now, next is the melting land based ice and glaciers. So, the melting of land based snow and ice contributes to rising sea levels. It is just contributing to increase in the rise of the sea levels. Then melting glaciers are expected to become a major significant contributor to sea level rise in the 21st century.

So this is very very important because we are seeing this type of change in the hydrosphere. Now projected sea level rise, new, newer research indicates that glacier melt cause even greater sea level rise. So if the glacier will melt continuously, definitely there will be the elevation in the sea level. So this is one of the very important impact in the atmosphere. And impact on coastal areas and low-lying islands.

Low-lying coastal areas, especially the nations which are having so many islands with little elevation, are at risk. So countries with large coastal populations will face difficult decisions on whether to invest in coastal defences or retreat to higher ground. So this is the impact on the coastal areas and low-lying islands. So now this impact we have seen and now I will discuss about the constituents of hydrosphere. If you will see the composition of seawater, generally salinity is one of the important factor.

Salinity seawater is a saline solution with a stable proportions of salt over geological period of time. So salinity is, many more, more in concentration. Then chlorine composes about 55% of all dissolved salts by weight. Chlorine is another important criteria. And sodium makes up around 31% of dissolved salts. And besides sodium, some other major elements include magnesium, calcium, sulfur, and potassium.

So these type of composition remains in seawater. Gases, if you will see, the sea water also contains small amounts of atmospheric gases like oxygen, nitrogen and carbon dioxide which are remaining in dissolved condition within this sea water. So this is the constituents of the hydrosphere now graphically if you just see the Oxygen is near about it is 85.790 percent by weight Hydrogen 10.67, then Chlorine 1.898, Sodium, Sodium 1.056, Magnesium 0.127, and so Sulfur, Calcium, Potassium, Bromine, and Carbon, Strontium and other dissolved gases remains And this is given by the Brian Mason, a famous geochemist, which is showing the elements present in the hydrosphere of oceanic water. So these are the different elemental concentration within the oceanic water.

So any body of water on Earth that contains liquid water is generally remains part of the hydrosphere as a result the hydrosphere is made up of a wide variety of strata including all the oceans like Pacific, Indian, Atlantic, Arctic and Antarctic oceans Sea, most of the

Earth water is salt water most of which is in the sea examples are Black sea, Caspian sea, Persian Gulf and Adriatic sea, Mediterranean Sea and the Red sea. Fresh water is also there on within the atmosphere but fresh water is much rarer than the salt water and is and is found in different different places. Surface water, sources usually consist of lake water river water stream water etc. Groundwater is the fresh water which is stored underground makes a very small portion of the fresh water on the Earth and glacier water water that glaciers have melted human influence is seen it has been seen because of the change in the hydrosphere So we know humans have a huge impact on the environment. The same applies to the hydrosphere also.

Humans have changed, the dramatically, due to the water pollution, what we are noticing today in the hydrosphere, river dams, wetland drainage, climate change and irrigation. Even though Fertilizer and sewage discharges into the water bodies also lead to eutrophication resulting in the aquatic environment being artificially enriched with nutrients. Excessive algal bloom can cause harmful hypoxia in water. So this type of condition is also very important in the hydrosphere because of the discharge of the sewage and fertilizer. Acid rain from SO_X and NO_X emissions, which SO_X and NO_X remains in the atmosphere.

So acid rain from SO_X and NO_X from burning fossil fuels causes acidification of the hydrospheric constituents, thereby damaging the surrounding ecosystem. Once the change will take place in the hydrospheric constituents, definitely it will damage the surrounding ecosystems. Finally by diverting or damming rivers what we are seeing our actions also change the hydrosphere's normal water flow. So normal water flow within the hydrosphere we are noticing that it has changed already. In other words, we can say it is damaging the surrounding ecosystem which are depending on water sources.

So if you will damage the hydrosphere, definitely you will see the ill effects in the surroundings. Now second sphere is the lithosphere. We have seen already in the lecture 2 when we were discussing about the interior of the earth that our earth's interior is made up of three important layers that is crust, mantle and core. And we have seen there also that lithosphere is nothing. It is just the crust plus upper mantle is called as the lithosphere. So it is the outer layer of the Earth.

It includes crust and upper part of the mantle. It is composed of strong and elastic behavior of the rocks. So structurally, we are strong. Lithospheres are strong and elastic. The lithosphere sits just above the asthenosphere, which we have discussed there also.

Again discussing, asthenosphere is a more ductile region of the mantle, which allows the tectonic movement within the Earth's system. So whatever tectonic movement we are getting tectonic means plate movement plate means your rock. The plates are nothing but these are composed of rocks. So whatever movements we are noticing in the plates because of the movement in the lithosphere and asthenosphere. So lithosphere are hard parts and the asthenosphere is the viscous part. So upon the viscous part, the hard part will move.

Once it will move, definitely the movement will take place. If you will see the constituents of the lithosphere by rock type, igneous rocks dominate. Near about 95% of the igneous rocks remain in the lithosphere. This classification was given by Clarke and Washington, a famous geologist. Then, shale constitutes near about 4%.

Sandstones constitute about 0.75%. Limestone comprises about 0.25%. And metamorphic rocks are formed from the alteration of one or more of these rock types. So, the point is, that within the lithosphere, we are getting all the three types of rocks because igneous rock near about 95%, but if you will see the sedimentary rock, sedimentary rocks are shale, sandstone, limestone, all are sedimentary rocks. So, near about your 5% they are remaining, near about five, 5% they are remaining in the lithosphere and remaining rocks, whatever we are having is the Metamorphic rocks and these metamorphic rocks are generally forming by the alteration of one or more of these type of rocks.

Chemical composition wise, if you will see the constituents of lithosphere, the continents are sialic in nature. We have read there also crust is of two types, sial, sial and sima. So, continents are sialic in nature, rich in silicate and aluminium minerals, silica and aluminium minerals. Ocean floor represents the upper sima. Which is more basic in nature and rich in silicate and magnesium minerals. Means the ocean floors are having the constituents of sima.

That is we have learned there also that sial is the top upper crust and the lower crust is the sima rich in the silicate and magnesium minerals. The lithosphere forms the Earth's rigid outer shell, essential for supporting landforms and facilitating the plate tectonics events. So movement of the plates takes place because of the lithosphere in the Earth's surface. The primary constituents of the lithosphere, a, are generally, if you will see the elemental composition, approximately 99% of the Earth's upper crust is composed of just 10 elements with oxygen alone making up nearly 50%. Oxide composition, if you will see,

10 major oxides account for more than 98% of the lithosphere, with silica being the most abundant, SiO_2, most abundant in the lithosphere.

And mineralogical composition, if you will see, the plagioclase feldspar. Plagioclase feldspar is a mineral, is the most prevalent mineral in the lithosphere. Apatite is among the least abundant minerals found in the lithosphere. So these elements and minerals are essential to the structure and composition of our solid crust. So this is the constituents which are showing that elemental composition, oxide composition and mineralogical composition of the lithosphere. Graphically, if you will see, again given by Clarke and Washington, elemental, as we have discussed, near about 50% is the oxygen composition, and next is the silicon, then alumina, then iron, calcium, sodium, potassium, magnesium, titanium, hydrogen, and remaining elements are percentage wise given.

So this graph shows the different percentage of the presence of the different types of element within the lithosphere. Here chemical composition of the lithosphere is given in terms of oxides as I have discussed earlier also that silica oxide remains in the maximum concentration followed by aluminium, calcium, iron, sodium, magnesium, potassium, ferric, water, titanium oxide and remaining oxides. So chemical composition wise your distribution of the oxides are also mentioned here. The mineralogical composition of the lithosphere shows that plagioclase feldspar is the most abundant mineral and apatite is the least one as I have discussed just now. The estimate is given by again Clarke and Washington.

You can see here apatite is the least abundant mineral. Whereas plagioclase feldspar, plagioclase feldspar, this one, this one, is the most abundant mineral in the lithosphere followed by alkali feldspar then amphiboles and biotite and quartz etc. So the above analysis generally gives only the average mineralogical composition of the lithosphere but it does not in any way represent the composition of the earth as a whole or even the crust as a whole. It is just giving the chemical composition, chemical and mineralogical composition. If you will see the importance of lithosphere, forest, what we are seeing present day, grazing land for agriculture and human settlements, all are on the lithosphere only, which is also a rich supply of minerals.

So the lithosphere helps in the supply of all necessary nutrient for plant growth it also works in tandem with the hydrosphere and the atmosphere to aid the growth of all living things. So, In brief, we can see the lithosphere is Earth's solid outer cell comprising rocks, minerals, soil, and tectonic plates, providing resources and shaping the planet's surface.

These spheres interact with water, shaping landforms, different types of landforms, and geological processes, influencing the water cycle, sustaining life, and Earth's dynamic systems. Whereas the hydrosphere includes all the water on earth, even oceanic water, fresh water, glacial water, groundwater and atmospheric water. All are within the hydrosphere and they are essential for life, climate regulation and different ecosystems.

Thank you very much.