ENVIRONMENTAL GEOSCIENCES

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Lecture-8

Erosion and Transportation

Welcome to the SWAYAM NPTEL course on Environmental Geosciences. We are continuing module two, in which we are discussing the types of weathering, erosion, transportation, and the geological work of wind, rivers, and glaciers. I have already completed lecture one, in which we discussed the types of weathering. Today we will discuss lecture two, which is about erosion and transportation. So, we have seen in the very first lecture that the exposed rock surfaces generally undergo weathering processes.

They are breaking and decaying because of the natural agents present in the atmosphere. So, here in this lecture, we will discuss erosion and transportation in greater detail. So, in this lecture, the important concepts related to erosion and transportation will be covered: the types, causes, processes of erosion and transportation, factors affecting erosion and transportation, and the impact of erosion. So, we will understand each point very systematically. Erosion. Erosion is a process that includes the destruction of existing rocks and the removal of the broken products to some distance.

So, this process includes first destruction, decaying, or breaking, and then the removal of those products from the site of destruction to a certain distance. Transport is an important aspect of erosion. It is usually done by wind, water, or ice. So, we can say that erosion is the combined result of weathering and the transportation of the resulting rock fragments, which ultimately leads to the wearing away of the Earth's surface features. The result will be that erosion alters the landscape, wearing down surfaces and reshaping the terrain.

Erosion gives rise to different types of landforms, such as valleys, canyons, or beaches, etc. This is because of the erosion processes. So, when the weathered material, as we have already discussed in lecture one, say this is the Earth's surface and the Earth's surface has some exposed rocks, if the top portion of the rock is loosening, breaking, or destructing, this process is called weathering. But if the loosened product, decayed

product, or broken product moves to a certain distance, meaning it is just coming out from the place where the weathering has taken place, then to a certain distance, this process is called erosion, and the removal of the broken rock fragments is generally termed transportation. So, when the weathering, transportation, and deposition occur.

This will deposit in some places. Deposition will take place collectively. Then it is called erosion. So weathering is only the breaking of rocks, whereas the broken rock fragments are transported to a certain distance. How does it transport? It transports with the help of water, wind, or ice, which is present in the atmosphere.

So then what happens? This water, wind, and ice, which we find on the Earth's surface, remove those broken products and settle them at a certain distance or at a certain site. This combined process is termed erosion. So if erosion takes place, what will happen? The landscape will change. Earlier the landscape was different; now this landscape will change again.

So some changes are occurring, and whatever changes we see on the Earth's surface are due to the weathering and erosion processes. That's why we get different landforms on the Earth's surface. Why do we get different landforms? Because we have valleys, canyons, beaches, and some different types of rocks, which we will also see in this lecture. Some rocks were earlier in this way, but after a few periods, they have just become like this.

What does that mean? This portion has just eroded. Just erosion has taken place. So this we will see in this lecture only. Now what are the types of erosion?

So, on the basis of geological agents, there are generally four types: wind erosion, water erosion, glacier erosion, and biological erosion. So, we will discuss these one by one: wind erosion and water erosion. Wind erosion is also known as aeolian erosion. Wind erosion is a natural process that occurs when strong winds move loose soil, sand, and dust from one place to another. It is a common phenomenon occurring mostly in dry sandy soils or anywhere the soil is loose, dry, and finely granulated. Wind erosion damages land and natural vegetation by removing soil from one place and depositing it at another place.

So here, you can see within the rock, we are getting the erosion, this erosion portion, and this has weathered, and the shape of the rock has changed. So, this is because of the wind erosion. This is also an example of aeolian erosion. Next, the types of wind erosion. Wind erosion occurs through three primary mechanisms.

First, the surface creep. It involves the rolling of larger soil particles ranging from 0.5 mm to 2 mm in diameter along the ground. Second is the saltation. It is the movement of medium-sized particles, typically between 0.05 mm and 0.5 mm, that are too light to remain in contact with the ground but too heavy to stay suspended in the air. Third is the suspension.

It involves the movement of very fine particles which are carried high into the air by wind. So, these wind erosion occur through these primary mechanisms, either through surface creep, by saltation, or by suspension. Now, water erosion. Water erosion is a natural geological process that occurs when water removes and transports soil particles. When the water is just removing and transporting the soil particles to a certain distance, then this is a good example of water erosion.

It can be caused by rivers, which are a good example of surface water, rain, snowmelt, runoff, or poor irrigation management. Some of the important types related to water erosion are splash erosion from raindrops hitting the soil. Then sheet erosion, where thin layers of soil are removed by overland flow. It will remove thin layers of soil by overland flow. This is the soil present on the surface of the earth.

So what is happening? Some of the thin layers of soil are being removed because of water erosion. Rill erosion, where small channels are formed by concentrated water flow. Some small channels are formed by concentrated water flow. And gully erosion, where large deep channels are caused by water flow.

So these are the types of water erosion. Now next is glacier erosion. Glacier erosion is the process by which glaciers shape the earth's surface by removing and transporting rocks and sediment. Glaciers erode land through two main processes. First is abrasion. The bottom of the glacier is rough with debris like rock and sediment which scrapes against the bedrock. At this place, you can see these are the debris of the bedrock, bedrock below. As the glacier moves, this process creates scratches or striations in the bedrock. Plucking. Glaciers can break off chunks of rock from the bedrock by exploiting cracks that may have already been present. When cracks grow together, the glacier can carry away the resulting rock chunks. So in the figure also, you can see that abrasion and plucking are the two important processes caused by glacial erosion.

Next is biological erosion. Biological erosion refers to the erosion processes facilitated by the actions of living organisms such as plants, animals, and humans, that disturb the soil and rock surfaces. These biological activities can accelerate erosion in various ways,

either directly or indirectly. Here are some key examples: plant activity. Roots from trees and plants penetrate the soil, causing physical breakage and dislodging soil particles, leading to erosion. Animal activity, burrowing animals loosen the soil. You can see in the picture also the animal is burrowing. These are the burrowing animals which are loosening the soil, exposing it to wind and water erosion.

So in this way, these are the different types of erosion. Now human activity is also very active in bringing erosion to the earth's surface. We are engaging in agricultural activities, so practices like plowing, overgrazing, and improper irrigation disturb the soil, remove protective vegetation, and increase erosion risk. Then there is construction and urbanization. Urban development, such as roads and mining, exposes soil to erosion by removing vegetation and compacting the ground. Deforestation, clearing trees and vegetation for agriculture or urban development, leaves soil vulnerable to erosion by wind and water. So these are because of human activity.

Now, types of erosion based on processes. Erosion is caused by two important processes: mechanical erosion and chemical erosion. First, mechanical erosion. Mechanical erosion is the process by which physical forces associated with running water, wind, etc., cause the breakdown and transportation of rock and sediment. This process occurs in five distinct manners. First is hydraulic action, second is deflation, third is abrasion, fourth is attrition, and fifth is cavitation. Hydraulic action, one by one we will understand, hydraulic action. This refers to the force exerted by the running water itself.

The flow of water can erode both the bed and the bank, particularly where the surface relief or gradient is steep. The greater the gradient or velocity of water, the more powerful the hydraulic action. It leads to the removal of loose material and the gradual deepening and widening of river channels. In extreme cases, it can cause significant erosion of the bedrock. So, at several places, we can see because of the running water, that is the river water, force is exerted by the running water itself.

The flow of water in the river can erode the bedrock. Some of the bedrocks remain safe if this is the river water, river water, which is flowing to a certain place, and inside just at the bottom of the water is the bedrock. So this bedrock, just one crack will remain if this is the bedrock, and through some weaker portion, some cracks are developed. Now what will happen is this will just widen; this crack will just widen in due course. And this type of erosion is taking place because of the hydraulic action. Because mechanically, it is just breaking down. Next is deflation.

Here you can see it is a type of erosion caused by wind. Hydraulic action is taking place because of the water. But deflation is caused by the wind. It is the process where loose particles like sand, dust, and small rocks are picked up and carried away by the force of the wind. This process typically occurs in dry regions where there is little or no rainfall and the ground is not covered by vegetation, which would otherwise hold the particles in place. In the figure, you can also see wind removes the surface sand, then deflation begins, then concentration of larger pebbles at some place, and large pebbles fit tightly as desert pavement. So this is the second process, which is deflation.

Third is abrasion. Abrasion erosion is a type of damage or wearing away of material that occurs when it comes into contact with moving objects. Here, abrasion is about surface erosion caused by contact between transported materials and surfaces. Transported materials are the broken fragments. It is just hitting the exposed surface, and then the erosion is taking place because of the scraping action.

Such type of action is known as abrasion erosion. It generally leads to the surface water, smoothing or polishing. So in this way, this is an example of abrasion. Now next is attrition. It is the process of erosion that occurs when rocks and other materials collide and are transported by wind or water.

Attrition is about the internal breakdown of materials due to collision with other particles. It is the grinding action. It leads to the size reduction and rounding of particles. So it is just a grinding action, just the loose materials hitting each other, and further it is just reshaping the structure of the particle. Even the size reduction is taking place, or rounding of particles is taking place.

So, this is because of the attrition. Next is the cavitation. Here, you can see that cavitation occurs when air bubbles in the water collapse and create a whirling action. This process can penetrate water into small fissures and pores in the bedrock, gradually enlarging them. The high-pressure air bubbles create powerful shock waves that cause the rock to fracture and erode.

Contributing to the widening of existing cavities and the formation of features like undercuts along riverbanks. So, at several riverbanks, you can see some of the undercuts, and these undercuts are because of the high-pressure air bubbles, which are creating powerful waves that are causing the rock to fracture and erode. So, these are some of the processes. Next, what are the factors that are influencing mechanical erosion?

Mechanical erosion, again, the hydraulic gradient, climate, nature of the bedrock, these are some of the factors.

A higher hydraulic gradient means the velocity of water increases, thus enhancing the erosive force of hydraulic action and increasing the overall rate of mechanical erosion. The next factor is the climate. Climate determines the amount of precipitation, which in turn affects the volume and velocity of water in rivers. Higher rainfall leads to larger volumes of water and potentially more erosion, especially in regions where rainfall is intense or seasonal. The nature of bedrock.

The type of bedrock, whether hard or soft, significantly affects how easily it can be eroded. Soft rocks, like shale or sandstone, are more easily eroded than harder rocks like granite. So, these are some of the factors which are influencing mechanical erosion. The next few factors are the hardness of transported materials. The materials carried by the water, such as stones, pebbles, and gravel, play a role in the erosive power of abrasion.

Harder materials can cause more damage to the bedrock, while softer materials may have less impact. Structure of the bedrock. The structure of the bedrock, whether it is layered, jointed, or fractured, affects how the water can exploit weaknesses in the rocks to cause erosion. So these are a few factors that are just explaining the breaking of the rocks. Now, chemical erosion.

Chemical erosion is also known as solution or corrosion. It is a type of erosion in which minerals from the bedrock or soil are dissolved in water and transported in solution rather than through mechanical processes like abrasion or attrition. This type of erosion typically occurs in the presence of water, especially in rivers or streams where the water reacts with the minerals in the rocks. In two different ways, this chemical erosion takes place. First is the dissolution of materials, and second is the transport in solution.

During chemical erosion, certain minerals in the bedrock or soil dissolve in the water. Second is the transport in solution. The dissolved materials, such as salts, minerals, or other compounds, are then carried by the water, typically to the sea or larger bodies of water. What are the factors influencing chemical erosion? The factors are the dissolving action of water due to carbon dioxide.

Rainwater or surface water interacts with CO_2, forming carbonic acid. This carbonic acid dissolves minerals, especially limestone and dolomite. The acid breaks down calcium carbonate into calcium ions and bicarbonate ions, which are transported in the solution.

Solubility of the riverbed. Limestone and chalk are highly soluble in slightly acidic water, making them prone to chemical erosion.

Granite and basalt are less soluble and more resistant to chemical weathering. Gypsum and salt dissolve easily, while granite and quartz are resistant. What are the factors affecting the rate of erosion? The factors are climate, topography, vegetation, soil type, Climate: wet climates with increased rainfall lead to faster erosion.

In dry climates, wind erosion dominates. Topography: steeper slopes lead to faster water erosion. Flat areas are more prone to water accumulation and slower erosion. Vegetation cover helps reduce erosion by stabilizing soil with roots. A lack of vegetation, as in deforested areas, increases erosion risk. Soil type: sandy soils are more prone to wind erosion.

Clay soils can erode through water runoff when improperly managed. What are the impacts of erosion? The formation of unique landforms, as seen on the land surface, is due to the erosion process. The second impact is the loss of topsoil. Topsoil is rich in nutrients, which we are losing day by day due to erosion, leading to reduced agricultural productivity.

Destruction of habitats and ecosystems. Nowadays, coastal erosion occurs due to this process. Erosion can lead to higher levels of sediment and pollutants in water bodies, affecting drinking water quality, irrigation systems, and aquatic life. Erosion caused by gravity can lead to landslides and rockfalls, causing significant damage to infrastructure. Coastal erosion can lead to the formation of beaches, cliffs, headlands, and sea stacks, contributing to the diversity of coastal landscapes. Methods to control erosion. What are the methods that can control erosion? The methods are vegetative techniques, such as planting trees, grasses, and shrubs.

Vegetation, including trees, grasses, and shrubs, helps to stabilize soil by anchoring it with their roots, preventing it from being washed away or blown away. Crop rotation and no-till farming. Crop rotation helps to maintain soil fertility and structure, while no-till farming reduces soil disturbances, protecting it from erosion and promoting healthy soil. Structural methods, such as building terraces, check dams, and retaining walls, also control erosion. Installation of sealed fences and windbreaks, and the use of geotextiles and other materials, all help in controlling erosion processes. What are the sustainable practices to control erosion?

Managing deforestation and reducing overgrazing. Deforestation increases the risk of soil erosion by removing plant cover. So managing forests and reducing overgrazing by livestock helps in preserving vegetation and maintaining soil stability. Implementing soil conservation techniques. Techniques like contour farming, strip cropping, and gully plugging can help to conserve soil in agricultural areas by reducing water runoff and promoting infiltration.

Restoration of wetlands and natural buffers. Wetlands act as natural filters and buffers, reducing erosion by stabilizing soil and slowing water movement. Restoring wetlands and natural buffers, such as those in riparian zones along rivers, helps in preventing erosion and maintaining ecosystem health. Now, next is after erosion. We have already discussed weathering, then erosion. Now, next is transportation.

Transportation refers to the movement of sediment from one place to another by natural agents like water, wind, ice, and gravity. It plays a key role in shaping the Earth's surface, contributing to the formation of landforms and influencing sediment deposition. Primarily, there are two methods of transportation. First is mechanical transportation. Second is chemical transportation.

Mechanical transportation involves the movement of materials through physical processes. It can help in three different ways. Suspension is the first way. Suspension means floating. This refers to the movement of particles or materials that are carried by a fluid like water or air and remain suspended for a certain period.

An example could be the transport of fine sediment particles by wind or water. Second is traction. By creeping and rolling, in this method, particles or materials move by being dragged or rolled along a surface. This is because of the rolling action. This is typically observed in the movement of larger materials such as rocks or pebbles which are moved by the action of wind or water flow.

Third is saltation through lifts and falls of material. Saltation occurs when particles are lifted off the ground by forces like wind or water and then fall back down on the ground, often bouncing along the surface. This is common in the movement of sand or smaller sand particles. Second is chemical transportation. Chemical transportation involves the movement of materials through chemical processes, often in solution.

This usually occurs when substances dissolve into a solvent like water and are carried along in that dissolved state. A very common example is the common substance like

carbonates and sulfates of sodium, potassium, and magnesium. They dissolve in water and are transported as part of water flow. This process is important in the natural movement of minerals and nutrients in rivers and oceans. Agents of transportation are the same, that is, water, wind, ice, glaciers, and gravity.

In the case of water, river, stream, ocean currents, and waves transport sediment. Water transports materials according to their size, shape, and density. Wind is the second agent, which transports fine particles like dust and sand, particularly in arid regions. Ice, that is glaciers, transports large amounts of rock, dirt, and debris as they move across the landscape. Gravity moves sediment downhill via processes like landslides, rockfalls, and debris flows.

Factors influencing sediment transportation. The velocity of the transporting medium is a very important factor. Higher speed can transport larger particles. The more powerful the transporting force, the larger the sediment size it can carry. Particle size and shape.

Smaller and rounder particles are more easily transported. Larger, irregularly shaped particles require more force to move. Density and composition. Denser materials like metals or rocks are harder to move than less dense materials like sand or silt. The next factor is the distance traveled.

Sediments transported over long distances tend to become more rounded and smaller in size due to abrasion and wearing. Environmental implications. You will see desertification, soil degradation, water quality degradation, loss of biodiversity, coastal erosion, increased frequency of natural disasters, impact on infrastructure, and climate change. These are some of the environmental effects we are seeing because of the erosion and transportation processes. Thank you very much to all.