Geomorphology

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Lecture-42
Coastal Geomorphology – IX

So, friends, good morning, welcome to this lecture series of geomorphology and today we continue with this a coastal geomorphology again, if you remember last class we are talking something about these coastal restoration and this barriers. So, we found that the barriers are the product of last 5000 to 6000 years in the late quaternary and the barriers they are mostly made up of sand.

And the sand it is migrate from its position and with time old barriers are vanished and new barriers are formed. And if there is no continuous sand supply to these barriers, so, with the time some of the barriers will be vanished completely and these coastal sand flats or these sand sheets, they are divided into segments of 100 kilometers of long and kilometers of width and height of about some meters.

And each segment is independent though, but at certain cases there are transitions occur that when sand from one sand sheet can we transport to other one at this transition zone and for each sand sheet we have source either by this offshore current or it is from this coastal cliff erosion or due to river and they migrate by this littoral currents and they have to this wind action or the eolian action.

And finally, where this coastal inlets or there tidal inlets or there mostly the sand it is lost there and it moves towards the deep sea and there is a the null point which is dividing the sand transportion zone or sand accumulation zone beyond which sand is not transported. And again it due to wave action it may come to the coastal zone and this is all about our the coastal sand management systems.

So, today we are going to discuss about this modern coastal conservation techniques, because in the last class we are discussing about the complete destroying of this coastal barriers. So, that means, we conclude there until unless we allow the sand to renew either due to Aeolian process due to fluvial process or the marine process this coastal barrier will be totally vanished and it has been noticed that nowadays, though these coastal barriers many of these coastal barriers they were formed during 5000 to 6000 years back.

But many of them are getting eroded; this is due to not continuous sand supply. So, now, the question arises why the continuous sand supplies not being taken place nowadays which was occurring 5000 to 6000 years back or 10,000 years back. So, this is one of these points these anthropogenic activities nowadays due to developmental projects we are carrying out in vast scale. So, part of this coast we have concretized. So, this due to this concretized that means we are burying these natural sand source, so that these sand is not continuously being supply to the system. That is why this system or these coastal barriers are vanishing.

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So the modern coastal conservation techniques that include calculations of the sand budget for each section of the barrier coast. So this is important calculation of this sand budgets so that means suppose we have a sand sheet in a particular coast, so how much sand is there, how much sand is in mobile condition, which is in the permanent condition of below the sea level that is it matters to us. It matters to us how much sand is mobile, that means how much sand is renewing there.

It is going out of this barrier system it is coming into the barriers system. So, that budget sand budget has to be calculated. So, with that calculation now we can backtracks it is that how much sand we can supply with this much exposure of this coast to how much sand we are producing from the cliff, how much sand we are producing from this river and how much sand we are renewing from this sea offshore currents.

So, these total calculation has to be carried out So, that we can restore our this sand barriers to larger extent. to correct negative budgets additional sand is provided at the upcurrent end of the each littoral cell. So, here it is important to suppose we are we want to restore these sand this barrier naturally. So, that means we have to supply this sand either artificially are naturally so, artificial supply of sand, it is not feasible to restore the natural systems.

So, that in an artificial way, we will contribute to this sand to this natural system. So, that due to some transportation agent in that sand will be contributed naturally to these barriers. So, in this way what we are doing nowadays, we dredge out this sand from this from one point and we put in the littoral current zone, so, that through this natural littoral currents the sand is redistributed and due to the redistribution this sand is automatically coming or supplied to this natural barrier system.

So, there are few localities or few points where these a modern coastal conservation techniques is applied. First is this communities. These communities which are staying near to the coast, then the coral reefs one component near to the sea coast, then water quality of the coast should be at same as it is then protect areas. The areas will be protected then estuaries and wetland that is near to the coast that has to be restored, then Historic site that has to be restored.

So, that means, these different sites along these coasts that has to be restored in a natural process. So, that is the main motto of this class today. So, now, these quantities of sand we are talking something about this sand budget of the system see is the quantity is measured in 1000s cube meter per day.

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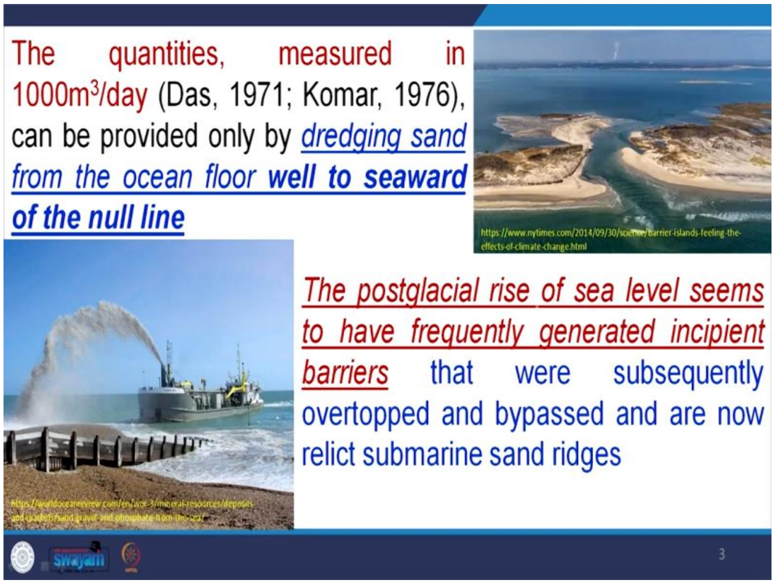

So, this quantity has to be measured and can be provided only by dredging out of sand from the ocean floor well seaward to the null line why because we know in last class. We are we can remember that the null line or the null point in a profile or null line along these coast parallel to the coast, this is a imaginary line which defines either sands to move seaward or is to move coastward. So, that null line and we know along this null line.

There is a breaker zone that there is null line it is lying just after the breaker zone, where this is sand is under suspension condition many times because due to high shearing effect of these waves breaking the effect of this wave with the bottom, so, that means whatever this sand is there, we are dredging out sand and we are putting it around this null line. Well seaward of the null line so that the backers.

The breaking waves, they can migrate this and they can transport those sands towards the coast and can redistribute along this a littoral current to this natural barriers. So the postglacial rise of sea level seems to have frequently generating incipient barriers that were subsequently overtopped, and bypassed, and are now relict submarine sand ridges. So what is it? What does it mean? The postglacial rise of sea level seems to have frequently generated incipient barriers.

Why? Because the rise of sea level postglacial, postglacial means, we have humid climate, we have warm climate. So warm and humid climate that means there are a number of rivers they are active, so that the river erosion capacity will be more. So more sediment contributed from this continent world and the rise of sea level is there. So that means whatever the sediment was contributing from this river.

That sediment was not able to go into the deep sea because of this barrier. As the water level is increasing. So that means those sediment remain along this coast or near the coastal zone and form these bars so there are subsequently overtopped and bypassed and are now relict submarine sand ridges. So now days they are somewhat submerged and they are forming these relict sand ridges.

So relict sand ridges some of them are stabilized sand ridges and some of them they are active nowadays it is Aeolian activity. So, those coasts which are emerged nowadays, so in that case, this sandbars they are reworked by this Aeolian system and they are active but some of these sand ridges they are all submerge conditions and they are the relict one that was formed during this postglacial sea level rise.

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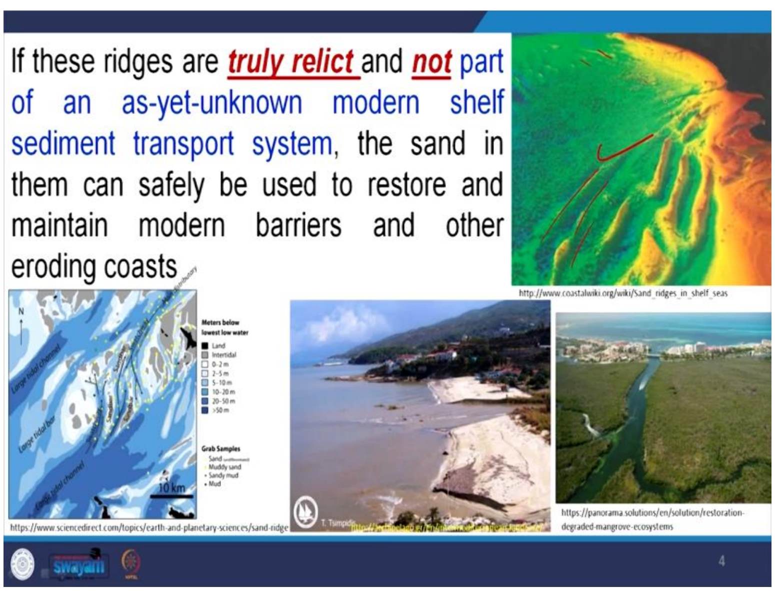

If these ridges are truly relict and not part of an as-yet-unkwon modern shelf sediment transport system, the sand in then can safely be used to restore and mainly modern barriers and other eroding costs. This is important to understand for this coastal management system, because we have sand ridges, which were formed during this postglacial rise of the sea level and there relict one for example.

If you see this figure here, some of the sand ridges you see they are under submergence, there are submerged sand ridges are there. So, those sub sand ridges they are not contributing actively to the modern sand ridges. So, that in an effective way we can mine those sand ridges and we can first identify those sand ridges which are in under submerged condition which are not contributing to the modern sand ridges, so that we can utilize those unused sand.

And we can mine those sand and will put in this zone which is the null area of this null line. So, that this littoral current or the wave and littoral current they can contribute those sand for formation of this modern sand ridges. So, this is an effective way of coastal management system. So, whatever so, far we are discussing about the say sandy source, how this sand can be managed, how this sand is supplied to the system.

And how this sandbars or the barriers can be restored naturally or artificially like that. So, now and we will talk about the muddy coast. So, coast once you move along this coast for example, you take example of Indian East coast or so, or West coast, the whole coastal system is not sandy. So, some part of this coast and muddy and like this barrier behind the barriers. Like the lagoons the mud flats, the tidal flats, the great sundarbans delta the tidal flats, the mud flats are there.

So, that means the whole coast is not sandy or as clean as we have discussed so far. So some patches are there which are muddy in nature, what is the characteristics of these muddy coast to how these muddy coast are generated and how they can be managed? So, once we say a muddy coast. That means it always comes in our mind that should be a common quiet condition related to other part of this coast. It should be a low energy conditions not water is not vibrant. So that means this mud has to deposited mud means it is clay sized particles silt and clay sized particles together it is called mud.

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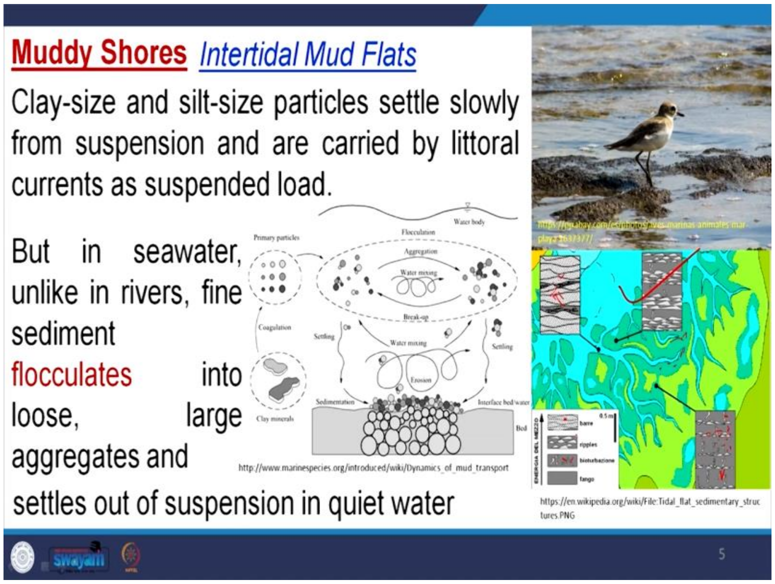

So, this clay sized and silt size particularly settle down slowly from suspension as the carried out by littoral currents and suspended loads. So, this suspension of clay, it takes lots of time, we have stokes law of separation of a sand silt clay in laboratory. So, you can see there that this clay takes maximum time to settle down in a particular temperature conditions. So, here the sea water is unlike a river or fine sediment flocculates into loose large aggregates and settle out suspension in quiet water.

So, we have clay particles clays are charged particles. So, these are together combined and finally, increase their size and flocculates and they settle down at the bottom of the sediment if you see here, this is the mud flat. Now, you see here, this area or this one, this is open sea and it is mostly it is sand here this tidal action is there. So, you are getting this herringbone type of cross bedding or cross stratification.

So, this is dominated by tide and this is this green area, this green area are the mud flats. So, if you see here within this mud flats these are bioturbated zones and this mud within that mud there are lenses of sand so, some flaser bedding is there some lenticular bedding is there So, here this are we are find we are getting some lenticules of sand within this mud, so it is lenticular bedding is there.

So, this gray color this is totally representing this mud and this is sand and these are bioturbated zones and mud flats they are very good for biological growth. Some animals they are particular animals, they are fed on this mud. They are fed on the organic matter associated with the mud. So, that is why in this mud flats not only this mechanical system this settling down of these clay particles that contribute for aggradations sediment deposition.

But also the organic influences there. These organisms also contribute to create some types of mud some excreta organic excreta, there is also contribute significantly to create sediments in basin within the basin they create sediments and finally the mud flats is aggraded.

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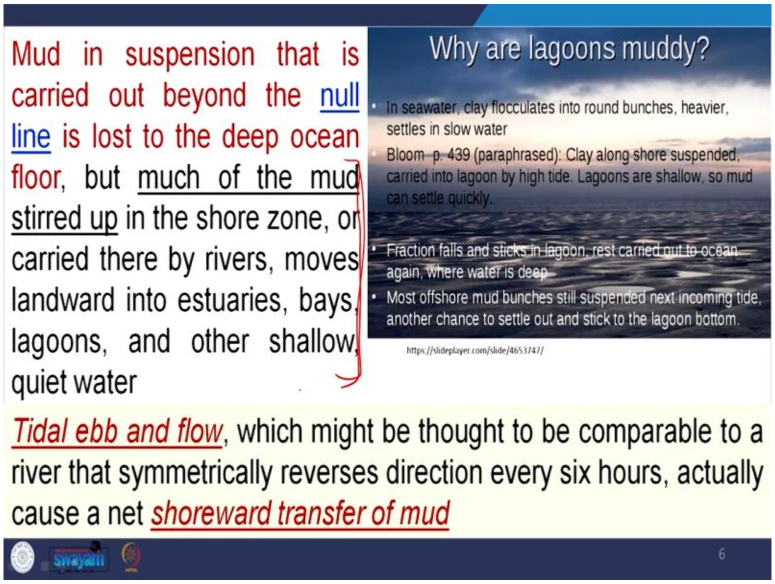

So, mud in suspension that is carried out beyond the null line is lost to the deep ocean floor. So, null line we know it is the line in imaginary line which is defining the sand to move either coastward or seaward. So, this line beyond that if mud is transported by these tides, so that will go into the deeper part of this ocean but the deeper part of ocean to settle down mud it takes 100’s of years because of this suppose for example.

If we take 4.5 kilometer is the general depth of this one for simple example. So, it up to this 4.5 kilometer to settle down, it will take 1000 or 100's of years, but much of the mud stirred up into the shore zone are carried there by the river moves landward into the estuaries, bays, lagoon and other shallow quiet waters environment. And so, now, you see here, we have distributing mud into 2 different parts.

One part of this mud we are taking beyond the null line, and we are settling down within that a deep ocean basin. And part of this mud we are tearing it up due to this wave action due to tides and taking towards the coast or depositing at the river mouth, depositing at the estuaries, then the lagoons the tidal flats, the mud flats in those areas were depositing there. So this tidal and ebb flow which might be thought to be comparable to a river that symmetrically reverse direction.

Every 6 hour actually caused the net shoreward transfer of mud. So, we know that this tides for every 6 hours we have neap tide we have ebb tides. So, this type of tides, so, every 6 hour it is reversing its direction. So, this at one time it is coming towards the coast and other time it is going beyond the coast or apart from this coast. So, that means, you can compare this system is a rivers system which is reversing its current at a different time scales in different opposite directions.

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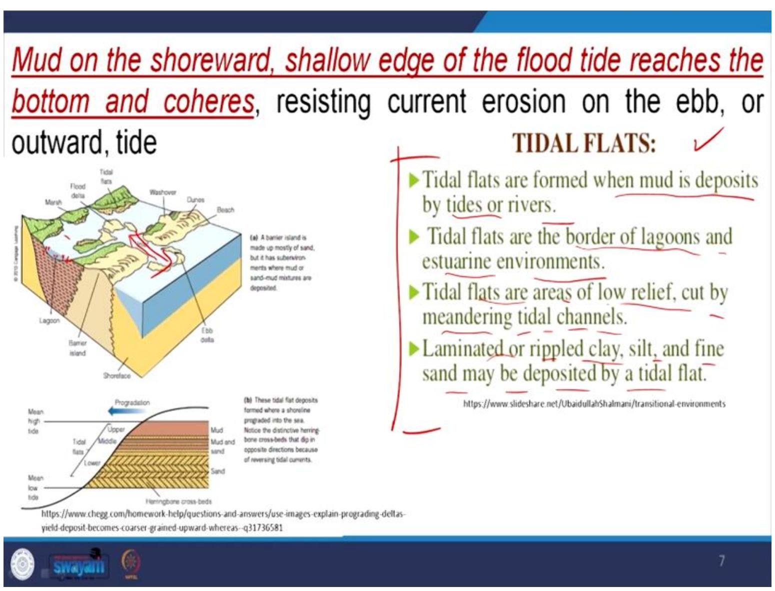

So, by this way, mud on the shoreward shallow edge of this flood tide reaches the bottom and coheres and resisting current erosion on the ebb or the outward tide it is very important to understand here. Suppose, this due to this high tide during high tide, the mud is coming towards the shores zone and it is filled with the lagoon, it is estuarine or whatever this shallow water environment is there restricted environment is there.

Once it is settles down to the bottom, its adhesive power increases. And remember when we are talking about this grain size and this erosion transportation deposition scale, the energy of this wave or energy of current is required to pick up a pebble is similar to this energy equal responsible are required to pick up a clay particle from this bottom. So, that means once this clay is settled down, so it is difficult again it to steer it up.

So that is why the shallow levels where this lagoons and this estuarine, the clay is settled down at the bottom, they remain there. So once remain there, this clay thickness gradually increases. So, that is why once it is settled down it coheres and it resisting current erosion of this ebb or outward tide. So here tidal flats if you see, tidal flats are formed when mud is deposited by tides or rivers, tidal flats are the border of lagoons and estuaries of the environment.

Tidal flats are areas of low relief cut by meandering a tidal channel, laminated or rippled, clay, silt and fine sand may be deposited in the tidal flat. These are the characteristics of tidal flat that mostly we are getting the fine grain material silt and clay. Similarly in this figure if you see here with in the coastal inlets at tidal inlet, this tide during high tide. The water is here and finally this clay has to settle down or the mud has to settle down here.

Once it is settling at this bottom, that means adhesive power it coheres, so that this power increases and due to this outward tide or due to in the low tide condition, there is remains there without steering up but at the same time, if we are moving towards these coasts or outward to the coast or to the deep sea level, these clay are not settled down. So that again during high tide that will again come to this say coastal site and finally settle down. So that is why with more and more tide, the clay content, the mud content at the tidal flat at this lagoons and finally increases.

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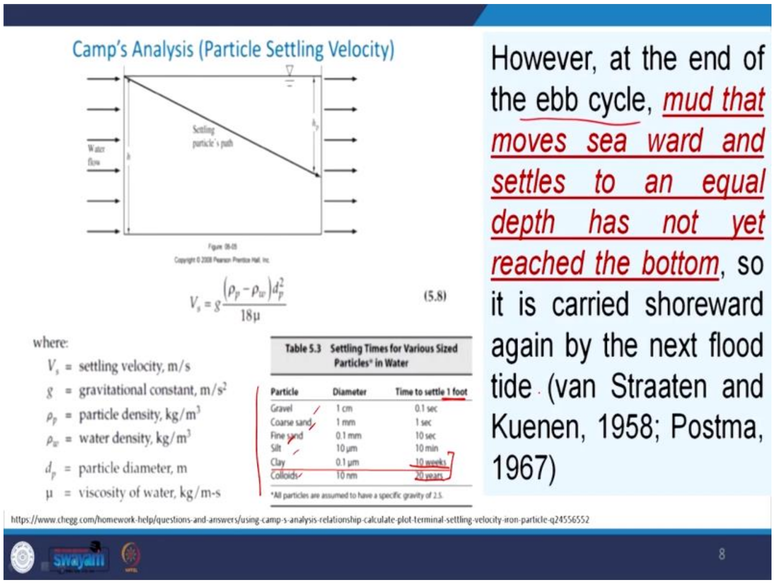

Now here is some of this analysis by Camp, it is settling velocity analysis it will say here we have different size classes, gravel coarse and fine sand, silt and clay and colloids. And if you see here this colloids and these clay to settle down up to 1 feet so 1 feet depth to settle down clay, it takes 10 weeks and this colloids it took 20 years for 1 feet of settlement. So, now imagine for every 6 hours we have tidal reversal, high tide and low tide.

So, even if this clay particle is there, it takes 10 weeks to settle down for 1 feet. So, that means, for these 6 hours there will be hardly a few centimeter movement is there. So, that means sand is in suspensive condition every time. So, that means due to this suspension and condition during high tide, the same clay again it comes to the closed and once this depth is less where in the lagoons they say estuarine's, they come close to the bottom.

And imagine at this periphery of this lagoons, and the estuarine the clay can settle down easily because due to this less depth, so, that means easily it can reach up to this bottom. So, that is why clay will be remain always in the suspension mode, and it will settle down near to this lagoons or in the lagoon and this estuarine's rather than in the deep sea conditions. So, here however the end of this ebb tide mud that moves seaward. And settled when; equal depth that has not yet to this stay at bottom. So it is carried shoreward again by the next flood tide and again it is enters into the estuarine and lagoons and it is settled down.

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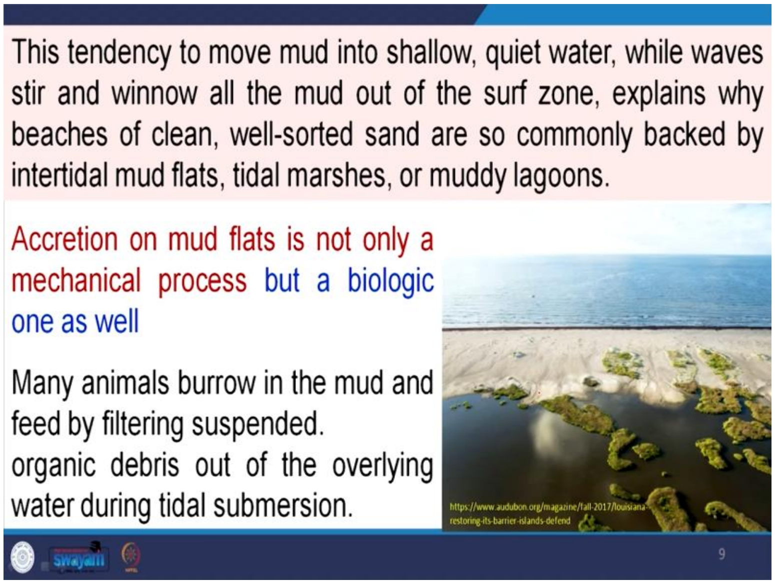

This tendency to move mud into shallow quiet water while wave stir and we know all this mud out of this surf zone explains why the beaches of clean well sorted sand are so commonly backed by intertidal mud flat tidal marshes and muddy lagoons that is important this is due to natural setting. So, that means due to natural setting and this coast you are getting sand and at this lagoons at this marshes tidal flats we are getting the mud.

So, this natural setting is due to this size particle this size fractions and due to the settling velocity and depth, because, at the same time suppose we are getting 6 hours time within 6 hours clay can reach up to this depth, but that means this depth that means at the periphery of this lagoons or these tidal flats or the marshes, but at the same time that this much depth it is nothing with respect to this coast the depth of this ocean.

So, that means remain within this water columns are suspension. So, during again high tide it comes to this coast. So, accretion on mud flat is not only a mechanical process, but a biological process also. So, as we have discussed earlier the biological process also contribute this settlement of this sediment at this coast. So how it happens so, many animals borrow in the mud and feed by filtering, suspended organic debris out of this over overlying water during tidal submersion.

So, some of these organisms tied like from the micro to macro, some of the organisms there stay in the tidal flats in the marsh and they fed on the mud they fed on the organic matter which remained within this water in the muddy water within that So, those organisms that excrete materials and those excreta if you see here, this photograph here.

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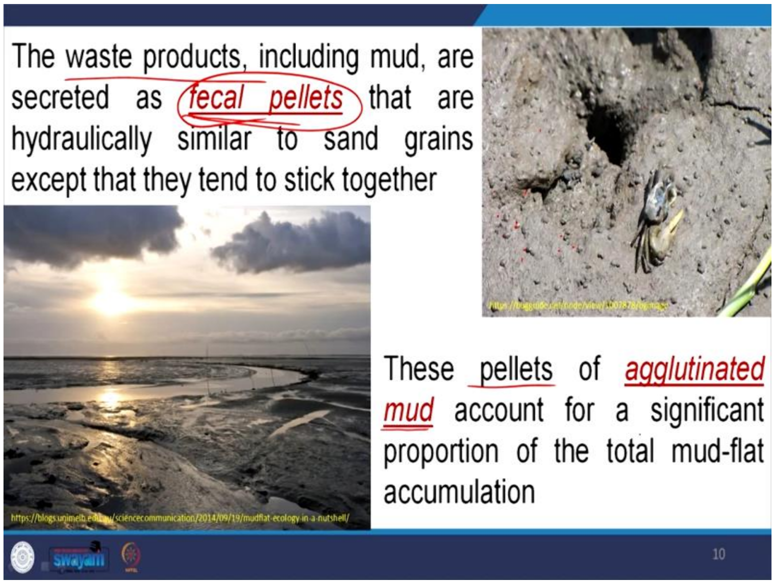

This waste product including the mud are these secret or secreted as a fecal pellets, so fecal pellets that are hydraulically similar to sand grains except that they are tend to stick together sand grain sizes. So these fecal pellets the excreta of these organisms, they are of mud nature. So, they stick together, the sand size particles are there, but they stick together but sand they do not stick together. So, these fecal pellets if you see this figure, these are the dots, these dots are the fecal pellets. So, these fecal pellets they settle down and within this sediment within this lagoon.

So, the tidal flats and they contribute to the sedimentation process of this lagoon, of the tidal flats. So, these fecal pellets of agglutinated; mud's account for the significant proportion of the total mudflat accumulation. So both by biological process and both by physical process, this sedimentation continues within the tidal flat. Finally, we are getting a tidal flat of mud rich environment. So, I think we should stop here. So thank you very much and we will meet in the next class. Thank you.