Earth Sciences for Civil Engineering Part-2
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Ground water
Module 4
Lecture No 20

Welcome back.

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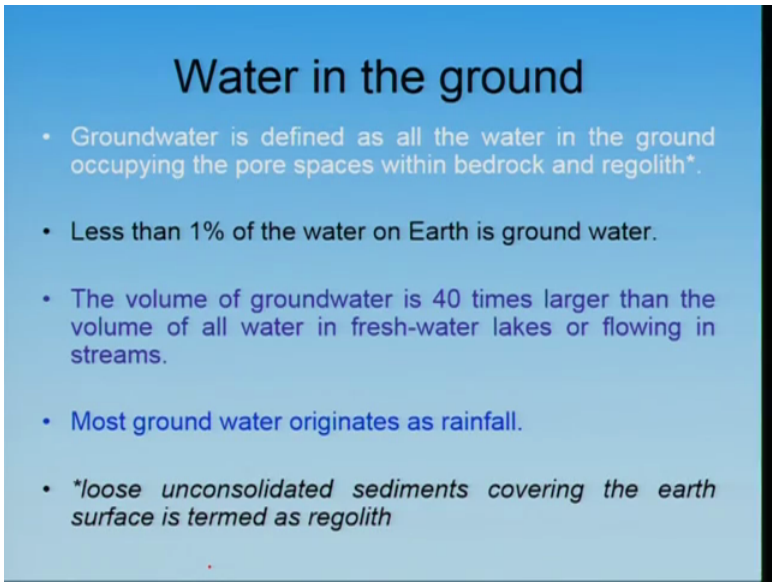

This is the last topic of our course, Groundwater. Now groundwater is extremely important for human kind okay and if we define the groundwater, it is defined as all the water in the ground occupying the pore spaces within the bedrock and regolith, regolith is the soil okay and around less than 1% of the water on the earth is groundwater. However if we take in terms of the volume of groundwater okay or the freshwater, 40 (per) times larger than the volume of all waters is the ground water like which is as compared to the fresh water in lakes and flowing through the streams.

Most groundwater originates as rainfall so this is just the brief explanation about the groundwater and this is what we were talking about, the regolith. Regolith is say loosely unconsolidated sediments covering the earth's surface in is termed as regolith. So in this discuss about the the porosity and permeability of the material which is extremely important for holding the water and we will talk about different type of aquifers, what are aquiclude, aquitard and few rock types

which are responsible for contamination as well as few earth's material which is which is helpful in purification of the of the contaminative groundwater.

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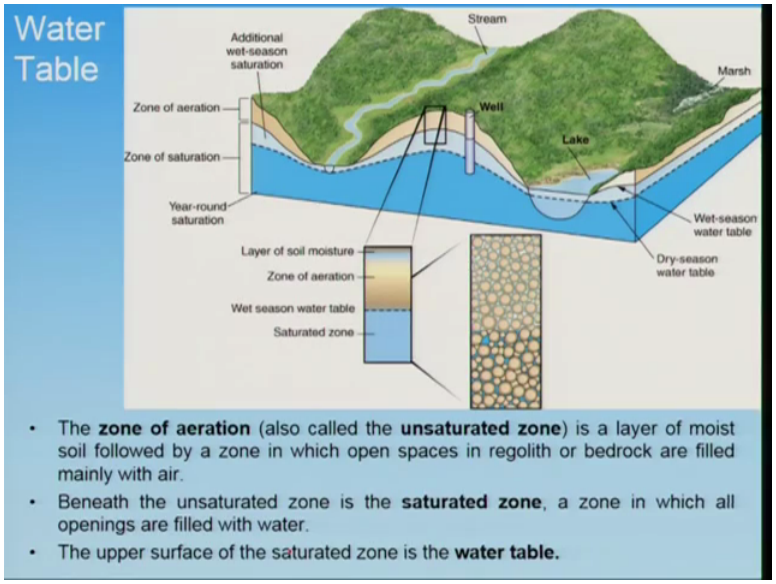

Let us move ahead. So if we take in terms of the water table first, what exactly is the water table we are looking at okay so water table, if we take the the section here okay then we have we can divide this whole section into the area which is having close to the the earth's surface, it will have very moist soil and then we have a zone of aeration and zone of aeration is comprised of loose material with open voids, it doesn't contain the water in in between that okay.

And then we have a saturated zone which will there where the pore spaces will be occupied by by the water okay and the contact between the saturated and the Eurasian zone is water table and this water table will keep on fluctuating so some time in in during the heavy rain and all that, if the percolation or the recharge is good then you may have the water table which going up okay, it may go up. That means it will occupy the space in the zone of aeration and that what we call is the fluctuation in the ground water table and usually it has been seen after the the heavy rains okay.

So in wet season, you will the the water table going reaching right up to the the in the zone of aeration whereas in normally in dry season, it will remain below and which remains always saturated. Nevertheless if we keep on extracting water or pumping water more compared to the

recharge happening in the area, you may experience lowering of a ground water table so the zone of aeration also termed as unsaturated zone is a layer of moist soil followed by a zone in which open spaces in regolith or bedrock are filled mainly with air. Then we have beneath that, beneath the unsaturated zone is the saturated zone, a zone in which all openings that is the pore space are filled with water and the upper surface of saturated zone is termed as water table.

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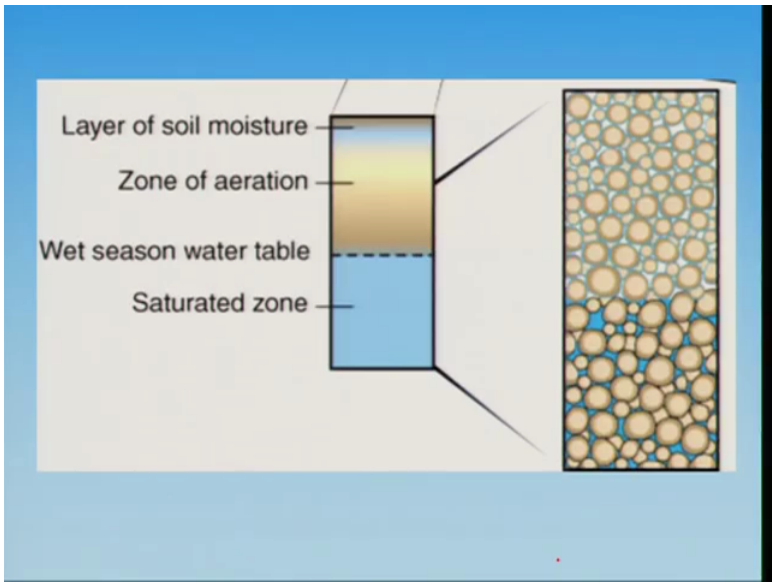

So this is what we were discussing in the previous slide.

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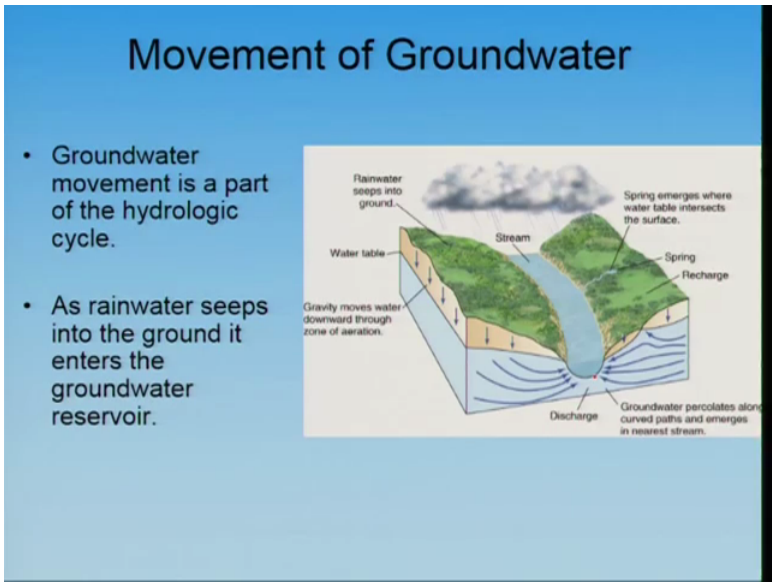

Now movement of groundwater, groundwater movement is a part of hydrological cycle so you have precipitation or rain and then it will percolate down below the surface and finally reaches through the the drainage or the stream which is flowing okay. The rainwater seep into the ground, it enters the groundwater reservoir which is the zone of saturation.

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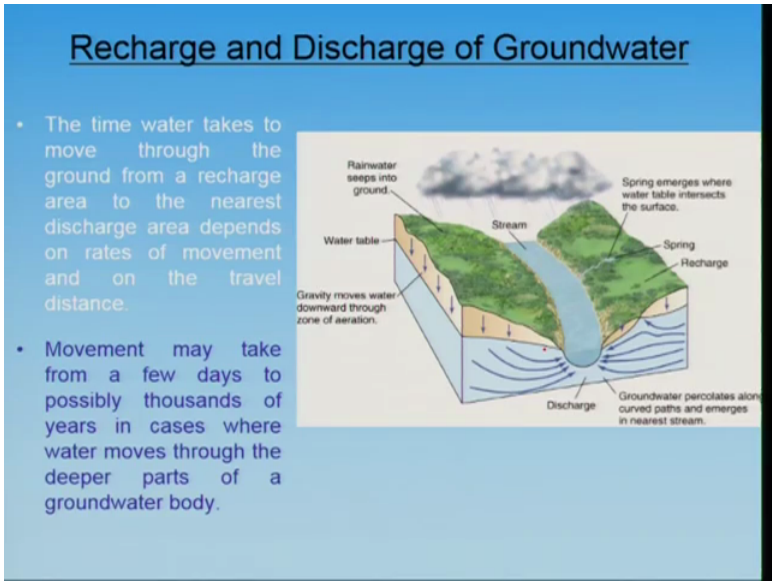

Now recharge or discharge of groundwater, this is an important part which usually we look at. If we are not having enough rain then we may face lowering of ground water. The time what it takes to move through the ground from a recharge area to the nearest discharge area okay. It depends on the rate of movement and on the travel distance okay. How far the discharge area is located and it depends on the the time will depend on the the travel distance okay between that two.

So you have to see that how much is the distance. Based on that it will take time so movement may take from a few days to possibly thousands of years in case where the water moves through the through the (deep) deeper part of the groundwater bodies okay and this has been experienced in many places at probably the Himalayan water or the water which got percolated in the Himalayan zone or the Indo Gangetic plain might take thousands of years to reach the ocean okay.

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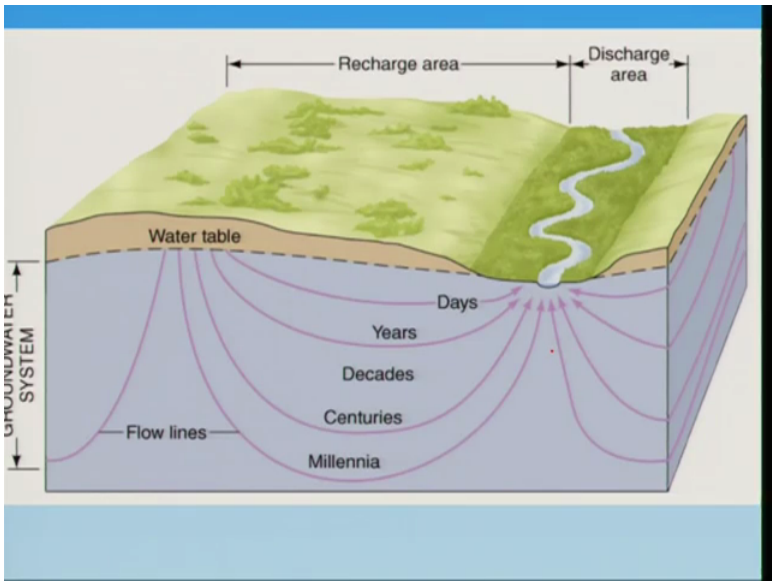

And this is what it explains okay that if you are having the shallower path, days, it may take years as you move further deeper, it may take millions of years to reach this one okay so this is the relation between the recharge and discharge areas.

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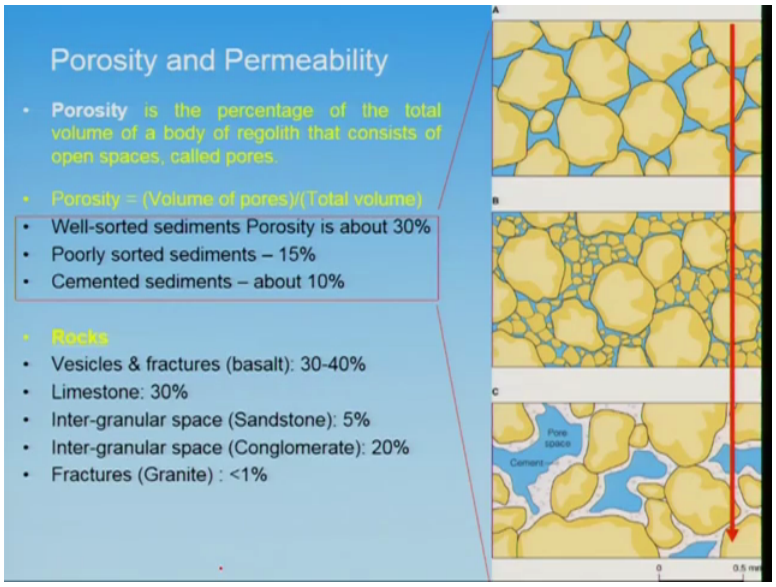

Further as I talked about the porosity and permeability is extremely important so porosity if we define is a percentage of total volume of a body of regolith that consists of open spaces called pores and porosity can be measured if you have the total volume and the volume of pores okay so volume of pores by total volume will give you the the porosity. Now, well sorted sediments, porosity is about 30%, poorly sorted sediments, about 15%, cemented sediments will percent okay so this is how it looks like.

So you are having well sorted material then you will have higher porosity. If you are having poorly sorted material, so you are having larger grains and then smaller grains and all that and then smaller spaces are available here. So blue portion is is showing the space occupying the by the by the water, occupied by the water and then cemented one will have the porosity of around 10% okay so you can refer to the different type of rocks we studied in the precious course, mainly the sedimentary rocks, metamorphic rocks and all that okay which will help you in understanding the porosity and permeability part.

Further if you look at the rocks then vesicular and fractured besalts, that is the igneous rocks will have comparatively higher porosity around 30 to 40%. The limestones will have around 30% because it has an capability of getting dissolved or it will be affected by the dissolution activity so you will have lot of huge cavities which will be available so it will have comparatively higher

porosity. Then intergranular space if you are having in the rocks, for example sandstone will have little less because it will be cemented and but you are having conglomerate then you will be having little bit higher porosity and then fracture granite will have less because fracture granites are granites are the massive rocks. So this is the one of the important parameter which one should consider when talking about the groundwater.

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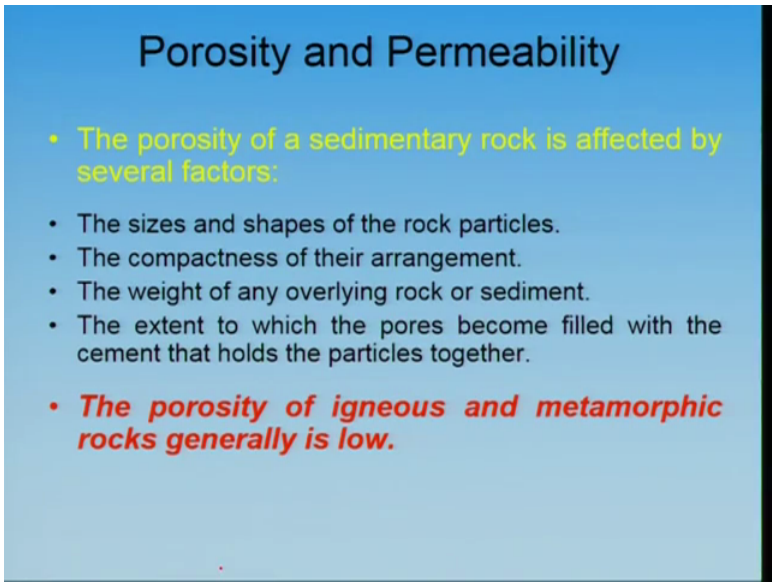

Then coming to the porosity and permeability further, the porosity of a sedimentary rock is affected by several factors. One is the size and shape of the rock particles or the grain size okay or the shape of the grain. The compactness of their arrangement. The weight of any overlaying rock or sediments okay because that may also result into compactness. Then the extent to which the pores become filled with the cement that holds the particle together okay. So the porosity of the igneous rocks and metamorphic rocks are generally low.

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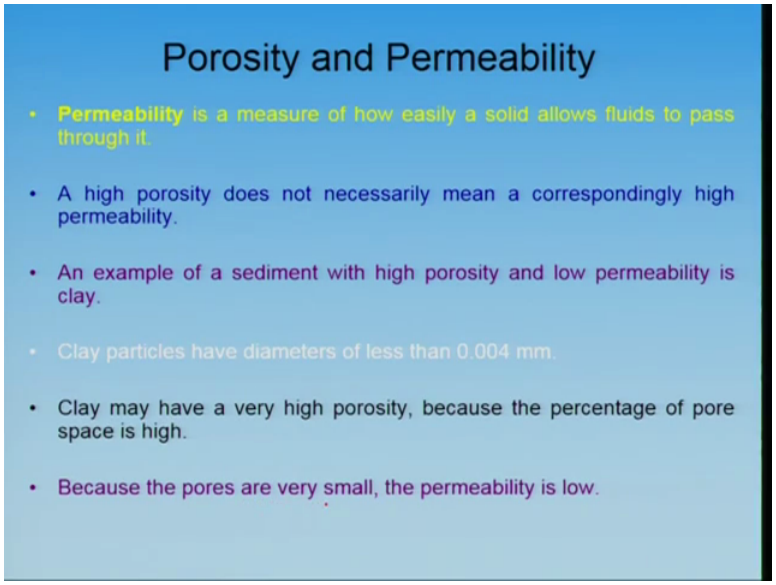

Permeability is a major of how easy a solid allows a fluid to pass through it okay. A high porosity does not necessarily mean a corresponding high permeability okay so for example in case of the clay okay, it is, it has high porosity but it has low permeability okay and this is because the clay particles have diameter of less than 4 microns so the particle size that is the clay may have very high porosity because the percentage of pore space is high but the the permeability is quite low here which did not allow or permit the the the water to flow through easily okay because the pore are pores are very small in size.

So though it has high porosity, it will have low permeability, so this you can compare with the sedimentary other sedimentary rocks like you are having sandstone or in case of the loose material if you are having sandy unit then it will have high porosity and permeability but in terms of the clay, even though it has high porosity, it has low permeability because it has an low pore (sh) size okay.

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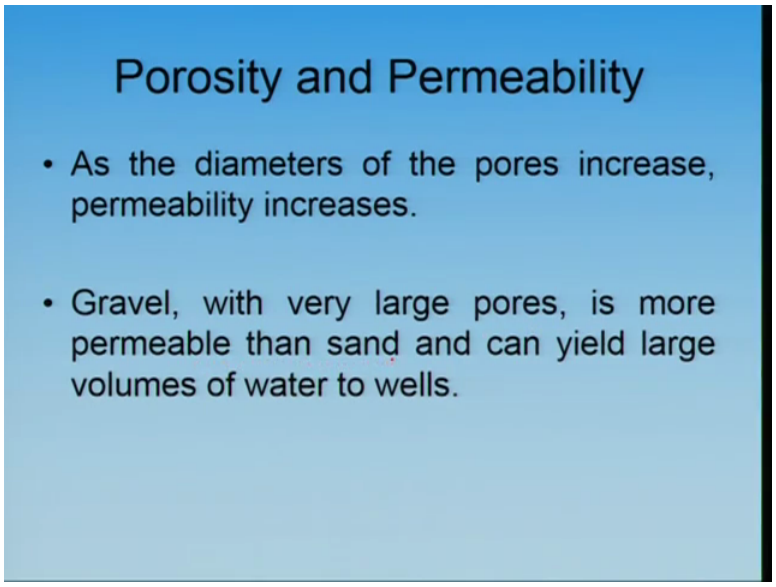

Further as the diameter of the pore increase, permeability will also increase okay so for example gravel with very large pore is more permeable than sand and can yield large volume water to wells okay.

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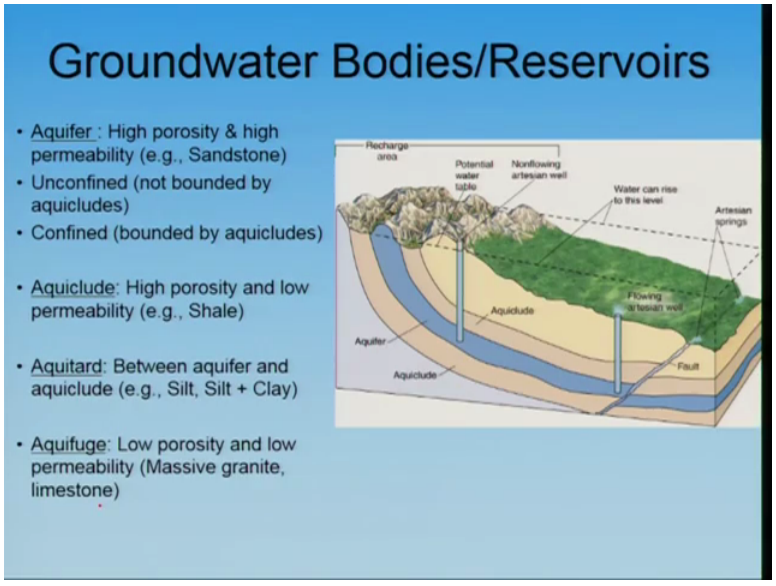

So groundwater bodies if we take we have what we termed aquifer, it is highly porous or we can say with high (per) porosity and high permeability okay. For example sandstones. An unconfined

aquifers are not bounded by aquiclude. What are aquicludes, we will talk very quickly okay. Confined bounded by aquicludes okay. So aquicludes are high porosity with and low permeability. For example shale or claybed so you will have claybeds are highly high high with high porosity and low permeability okay so those layers or the units are termed as aquicludes.

So if you have the unconfined aquicludes okay you will not be bounded by any or unconfined aquifers will not be bounded by any aquiclude areas okay. Whereas the confined one will be bounded by aquicludes so you have the layer with the high porosity but will not allow the water to percolate down or flow through okay. So this is an example of that so you are having, now this is an aquifer with the blue portion and this lighter ones are the aquicludes okay and so when when you drill a well to pump out the freshwater then you come across the confined the top layer and then you come and puncture this aquifer.

If you drill further sometimes you lose the the aquifer okay and in some places, even the fault okay plays an important role. This we have studied in geological structures and all that so faults plays an even (im) (Imp) important role or significant role in generating artificial wells okay. Where because of the gradient which the the aquifer is acquiring okay because of the topography this will result into the natural pumping up of the water on the ground. Those are the artesian wells okay and aquitard are between aquifer and aquiclude so example if you are having silt or silty clay layers or the units, they are termed as aquitard, aquifuge or aquifuge is low (permi) porosity and low permeability okay. For example, granites or limestones are the examples of aquifuge.

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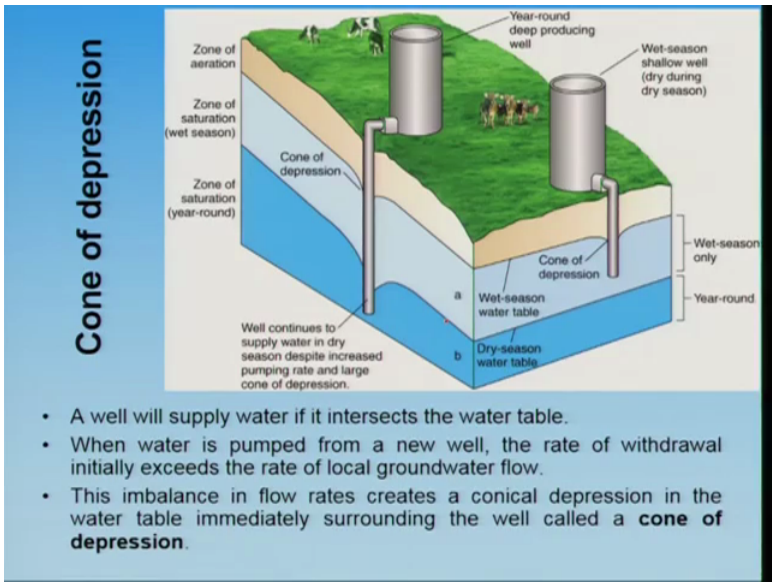

Now another important aspect of groundwater which are seen that if you keep on having excess removal of water then you will experience the that the depth of the groundwater increases but increases close to the areas where you are pumping out the excess water okay. So sometimes you may observe that you have to lower down your well okay or if you are having the submersible pump, you may have to go deeper and that happens because you develop a cone of depression. The surrounding areas, you may not have the change in the water table but at the place where you are pumping excess water, you may develop the cone or depression okay. So a well will supply water if it intersects the water table.

When water is pumped from a new well, the rate of withdrawal initially exceeds okay, the rate of local groundwater flow. So if it exceeds the local groundwater flow because this is the flow as the gradient here okay. That will imbalance result into imbalance in the flow rates creates a cone of cone conical depression in the water table immediately surrounding the well through which you are pumping out the water and that is termed is cone of depression.

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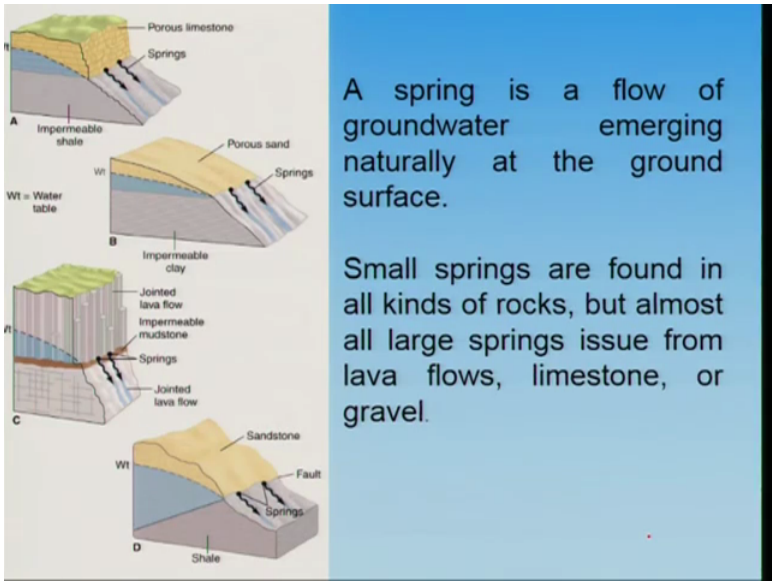

Now springs are most of the um the areas you will find the springs are again very natural phenomena and a spring is a flow of groundwater emerging naturally at the ground surface and small springs are found in all kinds of rocks okay but almost all large springs issues from lava flow. The areas which are having lava flows, limestone and gravels okay so if you go in Himalayas, you will find that the areas which are having the limestone as well as the gravel deposits will have lot many springs which are supplying groundwater to the areas okay.

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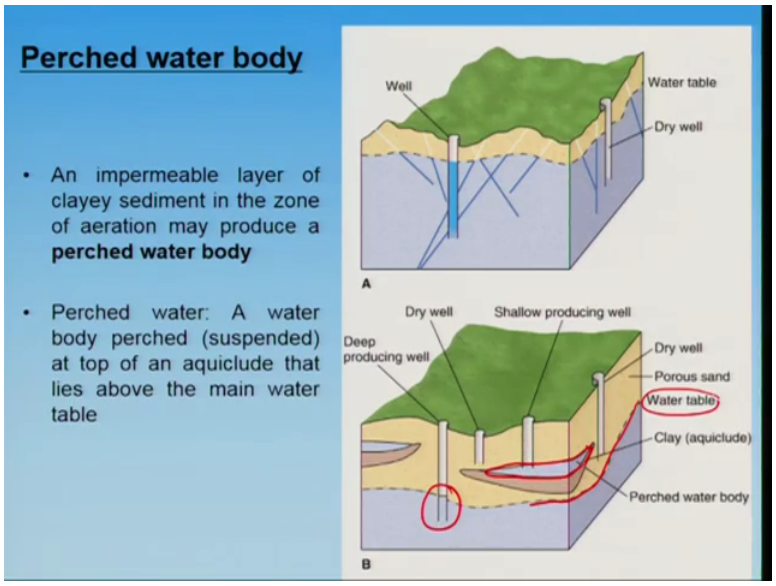

Now perched water table. What is that okay? The perched water table will be the the water body which is sitting above the normal water table and that happens because it has some base which we were talking about he aquiclude okay which may result into the formation of the water body here okay so in impermeable layer of clay sediments in the zone of aeration okay so as we were talking about the zone of aeration and then we are having zone of saturation okay and then in between the contact between that is your zone of or that is water table.

But perched water table you will find much above the normal water level so you may be happy that you you got the water, fresh water at very shallow depth but that may not last for longer period okay. You may this this body may dry out very fast if the recharge is not so much okay. So perched water table, a impermeable layer of clay sediments in the zone of aeration may produce the perched water body okay. A water body which is suspended at at the top of an aquiclude that lies above the main water table so this is sitting above the main water table.

This is your water table here. This one and it is sitting above the main water table so actually we should have got the water when you encounter the the zone of saturation okay but you can in few locations you may come across at very shallow depth but such water, water table or perched water body will not yield water for longer period.

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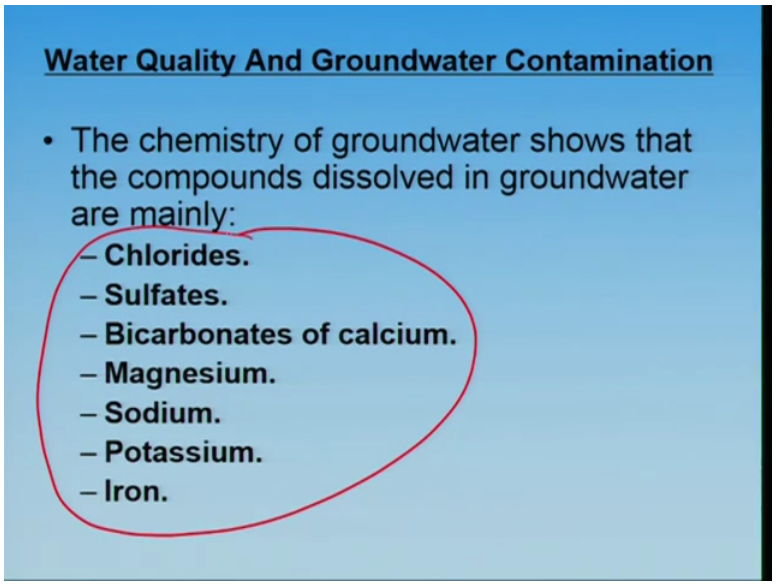

So water quality and ground (contamina) groundwater contamination this is another important aspect okay. So the chemistry of ground water shows that the compounds dissolved in groundwater are mainly chlorides, sulphides, bicarbonates of calcium, magnesium, sodium, potassium and iron and this all can be yielded from the rocks okay.

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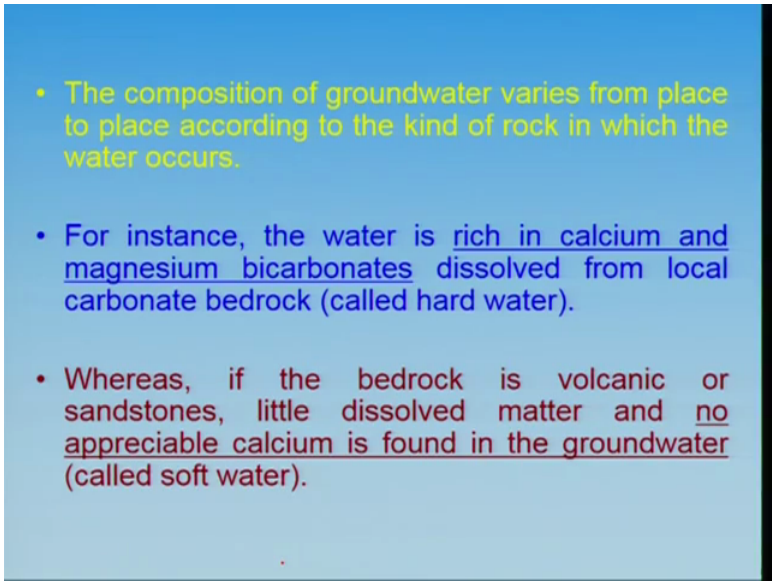

So the composition of ground water varies from place to place according to the kind of rock in which the water occurs okay. For instance water rich in calcium and magnesium bicarbonate dissolved from local carbonate rich rock okay and which is termed as hard water whereas if the

bedrock is volcanic in nature or you take sandstone little dissolved matter and no appreciable calcium is found in the groundwater which we call as a soft water. So this this is what we call the portable water okay.

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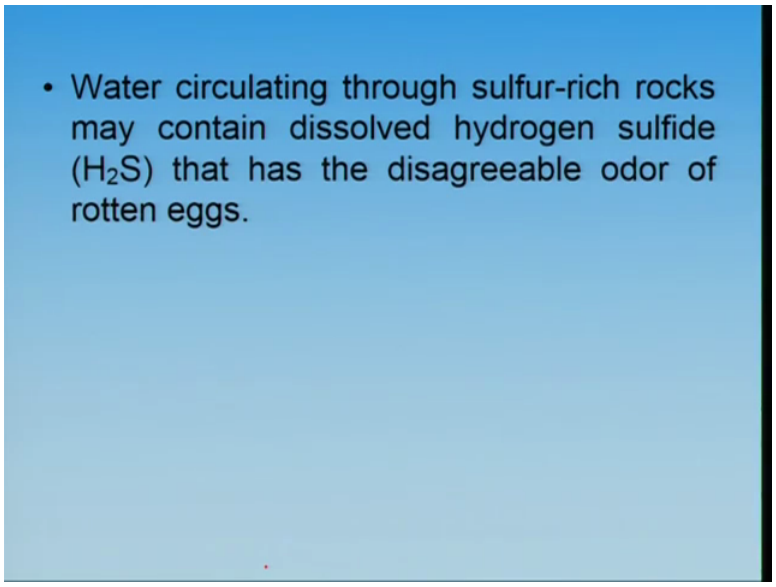

So water circulating through sulphur rich rocks may contain dissolved hydrogen sulphide. That has an odor of rotten eggs okay so this is nothing to do with the contamination by something else but it can be resulted from the the rocks which are rich in sulphur. The most common source of water pollution in wells and springs is sewage, drainage from septic tanks, waste disposal etc so this is also another bothering which contaminates the groundwater.

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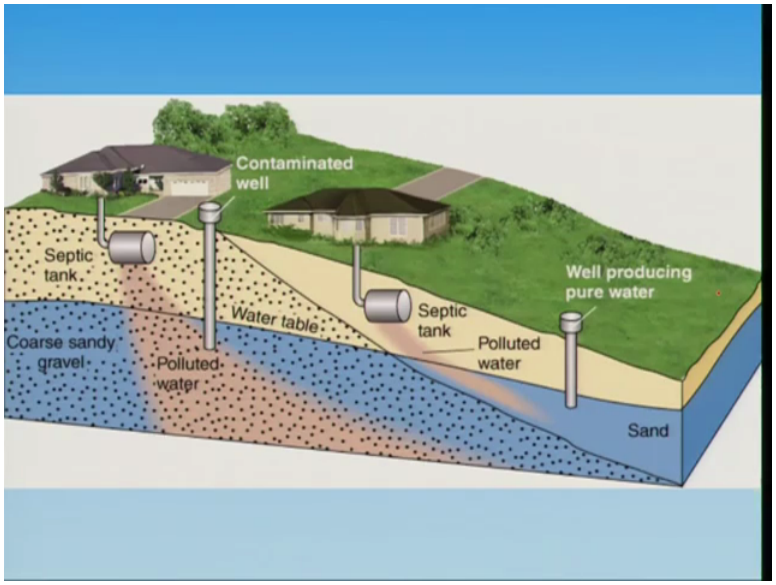

For example this one so if you are having a septic tank here and then though it is the well is away, you are not loving the pollutants to get cleaned okay so it will percolate down so you are having the unsaturated zone, you are having saturated zone so and you are pumping out the pollutants which are coming in this area. Whereas if you are having the septic tank and the the well is located far away then you may have the well which will produce pure water because you allow the contaminated or contamination to get purified okay.

So you are not having much of them. Apart from that, it is also important that what is the type of material in which you are having the the water table okay or water body so the sand is one of best which acts as an purifier okay whereas here we are having coarser sand with gravels okay so it will not clean or purify the water as compared to what we see in the sandy aquifer.

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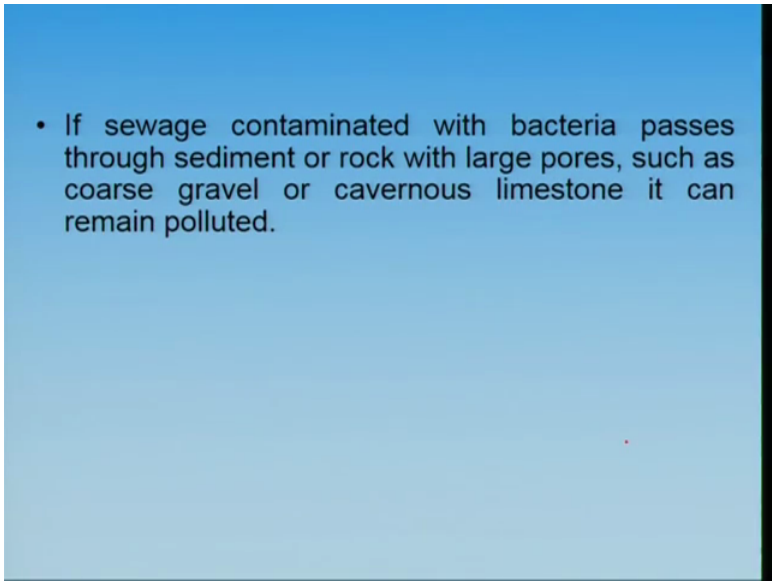

So if the sewage contamination with bacteria passed through sediments or rocks with large pores spaces okay. Such as coarse gravel or limestone which will have like cavities okay, it remains polluted.

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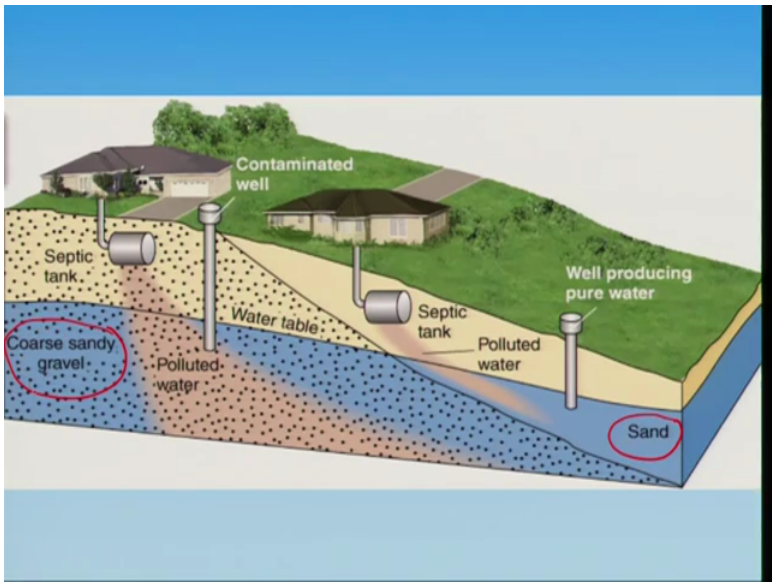

So here if you compare the coarser gravel or the coarse sandy gravel, it has large coarse space as compared to what we see in the sand okay so this will remain polluted okay.

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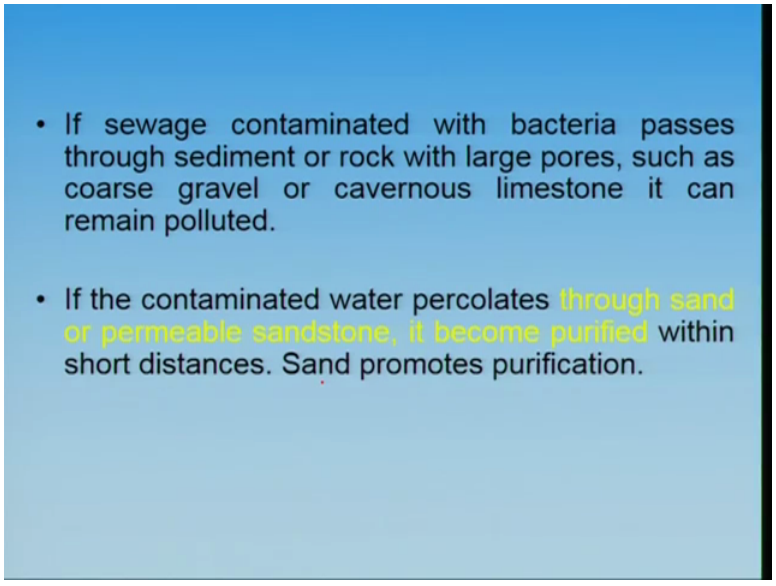

If the contaminated water percolates through sand or permeable sandstone it becomes purified within short distance okay so sand promotes purification.

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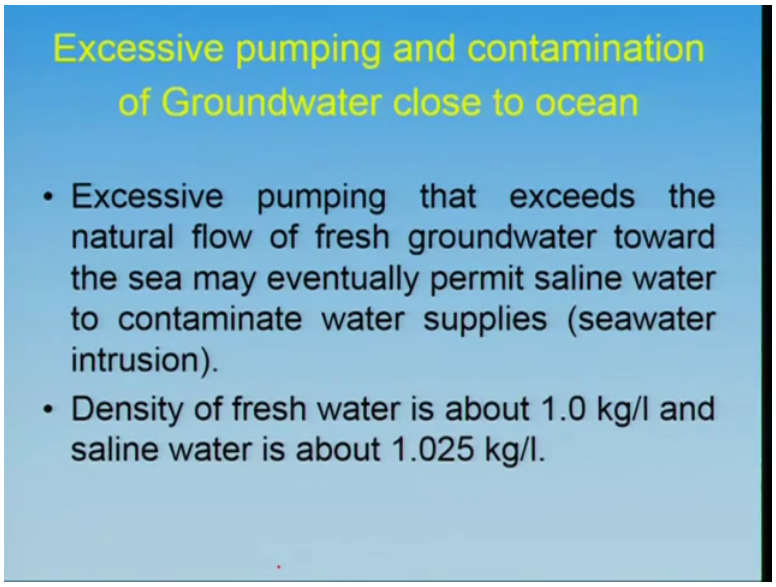

So excess pumping another one contamination of the groundwater close to the ocean, if you keep on pumping the the fresh water then you are inviting the the saline water to intrude into the aquifer okay and this is because the density of the fresh water is about 1 kilogram per liter and the saline water is bit heavier so this will contaminate here aquifer and this phenomena we say the intrusion of saline water or sea water into the fresh aquifer in the coastal areas.

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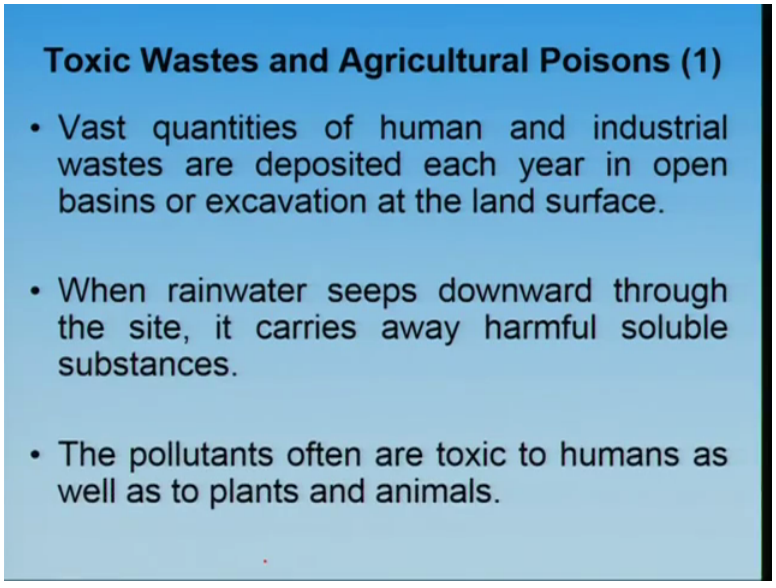

Now toxic waste and agricultural poisons. Vast quantity of human and industrial waste are (dis) deposited each year in open basin okay or excavated at the land surface so without having understanding that what type of material is sitting below okay we keep on dumping the toxic waste okay and that can contaminate the groundwater so when rainwater seeps down through the site, it carries away harmful soluble substances and that will result into the contamination of ground water.

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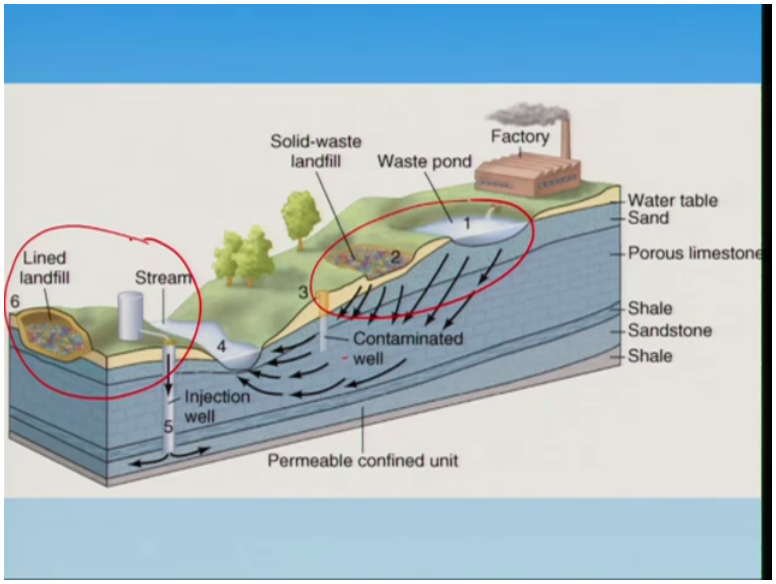

So this is an example that if you this is an open dumping place okay. So course we say that it is away from houses and it's away from the factory but it will keep on contaminating here so it is always advisable to that to pump the the waste down deep below where you are not having any chance of putting your wells close to that actually or you can do the another advantage which you can take is you lain up the land fill so that you doesn't allow this this the toxic material to seep down into the the aquifer so this will create problems and if you adopt this one, this will help you in having pure water okay.

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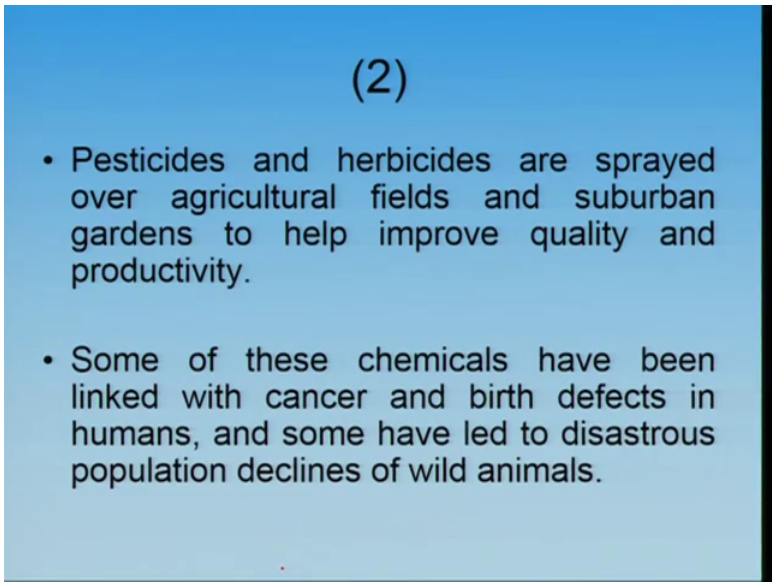

Pesticides and herbicides are spread over agricultural fields and suburban gardens to help improving quality of or productivity okay. Some of these chemicals have been linked with cancer and birth defects in humans and some have lead to disastrous pollution declawing in the wild animals also.

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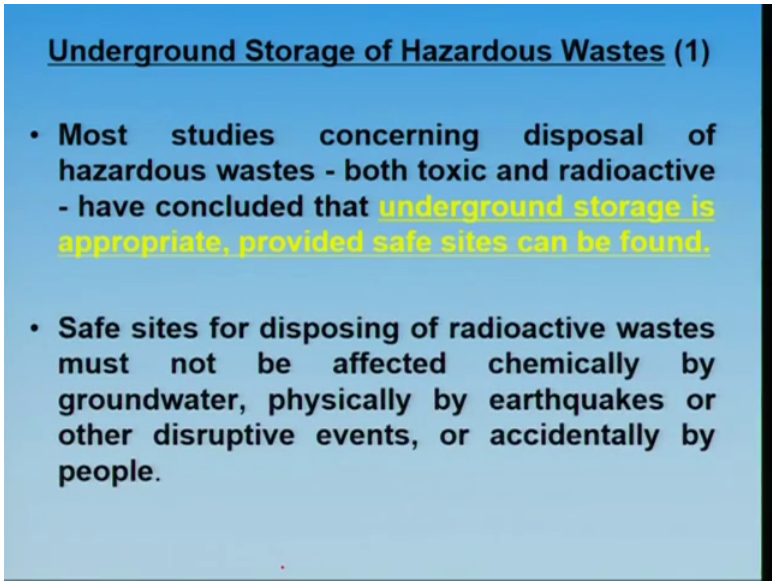

Underground storage of hazardous waste. Again we need to have understanding of the landscape and the subsurface geology so most studies concerning disposable disposal of hazardous waste both toxics and radioactive have concluded that underground storage is appropriate provided safe sites can be found. So safe sites for disposing the radioactive waste must not be affected chemically groundwater one so that you can do by injecting at the deeper part.

Second physically by earthquake okay so they are not affected physically by earthquake okay so the deeper portion will not have any effect on that okay or disruptive events or accidentally by people okay so you cannot have the place where you dig and you open up the the waste disposal pond okay so you may have to locate such an area which is not affected chemically by that groundwater okay. So if you put deeper things at the deeper level then you may save yourselves from contamination. Of course other part is that you should not also have the fault lines close to that which may rupture the waste disposal areas okay.

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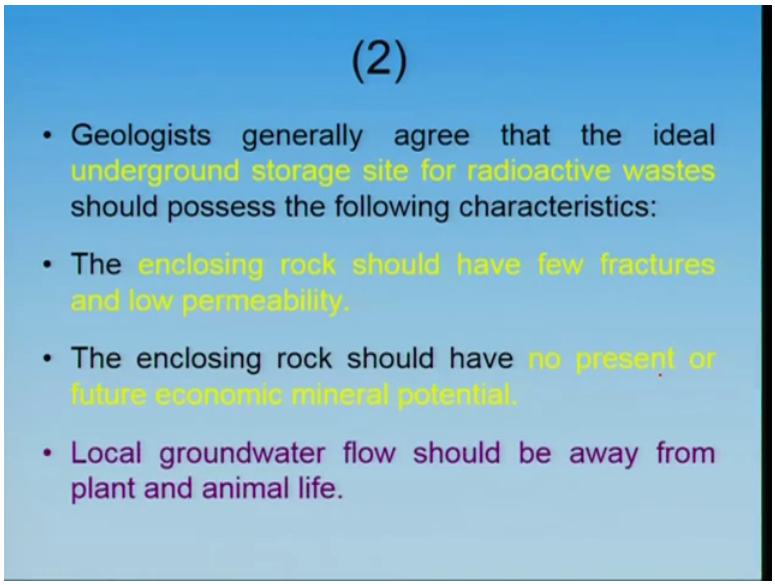

So geologists generally agrees that the ideal underground storage sites for radioactive waste should posses the following characteristics okay. The enclosing rocks should have few fractures and low permeability. The enclosing rock should have no present or future economic mineral potential because may be after 100 years or 50 years, you may come across that you need to have some mineral exploration and you start digging and you will expose the waste disposal areas

okay so that should not be the area should not have any future mineral exploration. Local groundwater flow should be away from plants and animal life okay.

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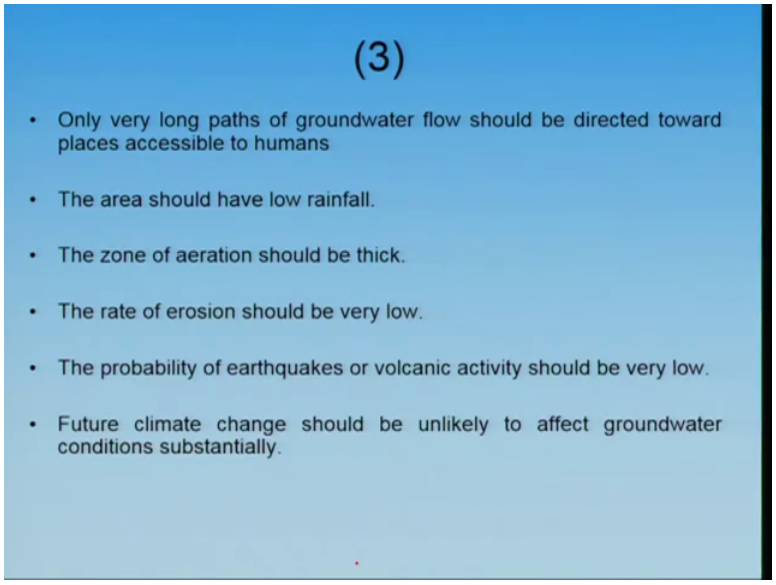

Only very long path of groundwater flow should be directed towards the places the accessible to humans okay so that it get eventually purified until it reaches the the groundwater where human settlements are there okay so the area should have low rainfall, the zone of aeration should be thick, the rate of erosion should be very low. The probability of earthquake or volcanic activity should also be very low in that area. Future climate change should be unlikely to affect the groundwater condition substantial.

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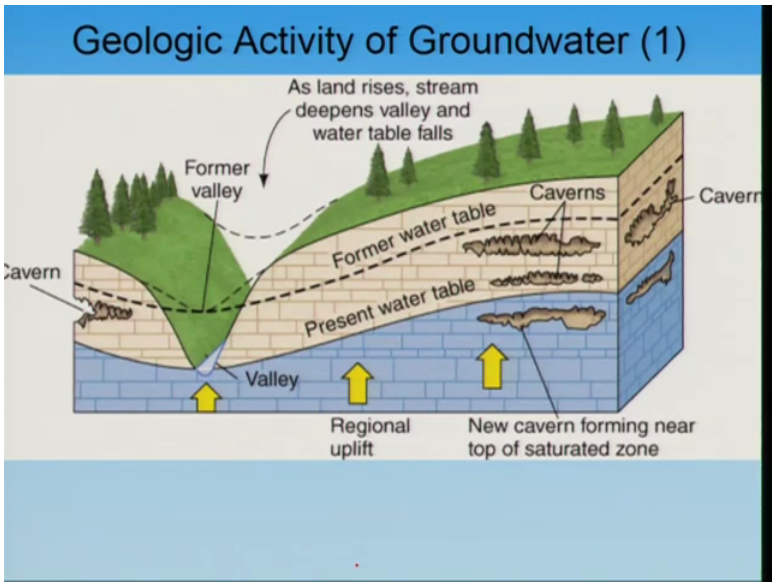

Geological activities of groundwater if you take then what you have it that these are the mainly the limestone which have the the capability of having cavities will act as in the areas which will result into more contamination okay. So for all rocks in the earth crust the carbonate rocks are amongst the most readily attacked by dissolution activity so such rocks or the area is comprised by such rock should be avoided for selecting the site for the disposal.

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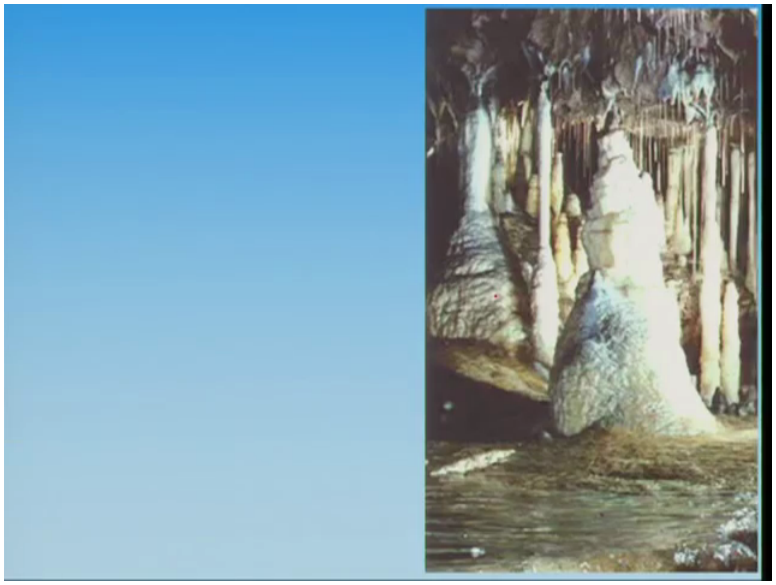

So I will end here. Thank you so much and best luck for your exams okay.