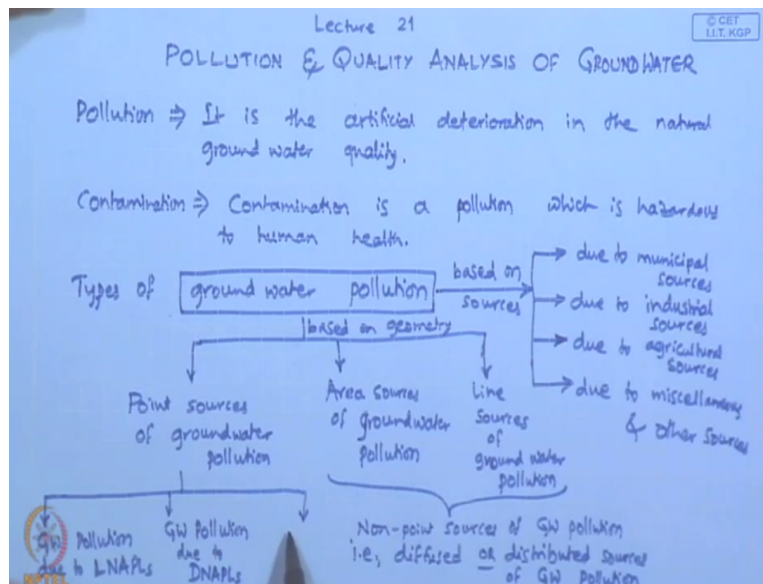


**Ground Water Hydrology**  
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**Module No # 05**  
**Lecture No# 21**  
**Pollution and Quality Analysis of Ground water**

Welcome to this lecture 21 in the module on pollution and quality analysis of ground water.

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And so in this we will discuss with the meaning of pollution first and this pollution it is the artificial deterioration in the natural ground water quality so obviously in this we are focusing on the deterioration declined which has come in the natural in the quality of natural ground water by artificial needs and here we should make a distinction between pollution and contamination.

So here this contamination is pollution which is hazard to human health .So contamination is also a type of pollution only and here. So it causes the hazard or a danger to the human health whereas pollution it may or may not poses to human health once it posses danger to the human health then it is known as contamination and there are various sources of pollution of ground water.

So here let us briefly discuss that is the types of ground water pollution so this ground water pollution. So it can be classified in the various categories based on various criteria like say

the classification based on sources based on the sources of pollution of ground water. So it can classify into this is ground water pollution due to municipal sources.

Then followed by the ground water pollution due to industrial sources then the next category of ground water pollution is the ground water pollution due to agricultural sources then lastly the ground water pollution due to miscellaneous and other sources and based on the geometry.

So this ground water pollution can be classified into that is point sources of ground water pollution and so the next category is the area sources of ground water pollution and of course yeah this is line sources of this ground water pollution. So these area as well as line sources of ground water pollution so they are also known as non point sources of ground water pollution GW is the abbreviation of ground water.

So this is ground water pollution or they are also known as distributed or diffused or distributed sources of ground water pollution and here and against of this point sources pollution we can further group this into further categorize this into ground water pollution due to LNAPLS because i will give the expansion of this just a minute later.

Next is ground water pollution due to DNAPLS and lastly the ground water pollution due to inorganic and others. So all this is part of the all this comes under the point sources of pollution so here this LNAPL

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LNAPL ⇒ Light non-aqueous phase liquid ; [e.g. petroleum products]  
DNAPL ⇒ dense ————— do ————— ; [e.g. Crude oil] etc.

Municipal sources of Gw Pollution :

- Sewer leakage
- Liquid wastes
- Solid wastes

[e.g.; dry cleaning pollutants, automobile pollutants, aviation pollutants, electric circuit board pollutants]

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So this LNAPL is the light non aqueous phase liquid similarly DNAPL is dense non aqueous phase liquid so here this LNAPL can give the example of say it is petroleum products and this crude oil etc... And DNAPL so this is the example you can give is the dry cleaning pollutants comma automobile pollutants the engine oil etc aviation pollutants the pollutants which are used in the aviation sector then the electric circuit board pollutants.

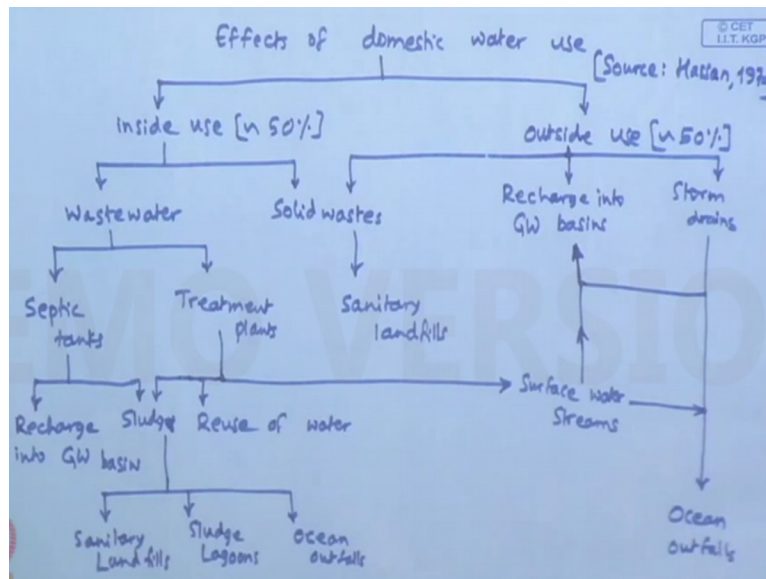
So all these are heavier than water so therefore they are included in this dense non aqueous phase liquid phase liquids whereas this petroleum products. So that is the crude oil etc then petrol diesel kerosene all that so they are lighter than water. So therefore they are included in this light non aqueous phase liquid or say LNAPL here and since they are light they will be in the they will be spread on the water table.

Whereas this dense this DNAPL because they are heavier than this one so they move or they filtrate further below the water table and therefore that is dense blooms or within the aquifer below the water table and then this so this inorganic or others. So they can say some metals salts etc so these are the some of the this one and this be the sources of pollution they are not restricted to a point so then they are known as diffused or distributed source of pollutions and in this case.

So the pollution source may be extended over a line or it may be distributed over an area either in plane or in three dimensional sources. In that case all of them are included as non point sources of ground water pollution. So this is the classification based on the geometry whereas the classification based on the sources is it is a classification starting with the municipal sources of ground water pollution followed by industrial surface agricultural sources.

And then this the miscellaneous other or other sources of pollution now let us discuss the municipal sources of ground water pollution in this so we will be we will be covering that is the sewer leakage followed by liquid wastes followed by solid wastes so these are the three categories and now let us discuss the municipal sources of ground water pollution and here the municipal sources of ground water pollution.

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Let us go to what happens when water is used for domestic uses the effects of effects of domestic water use obviously. So all this when water is used for domestic purpose so it can be for an inside use or it can also be for an outside use so within the inside use that means within the building or any other facilities so here it can be so this is this chart is taken from has in 1974 in which so there is a very good categorization of the effect of domestic use.

So here inside the it will result in say waste water it may also result in say solid wastes so the solid wastes are also generated when it is used for outside use and here so in the outside use the water is used outside so it may be it may go as a recharge into ground water basins or it may go into storm drains or storm drains then this waste water so it can be it can go into septic tanks or it can also go this move through this sewers into say this treatment plants.

The solid waste hey will go to sanitary landfills and storm water drains it may either go to ocean outfall of course ocean is the last this one may be before that it may be getting discharged into various streams or rivers or seas or (( )) (19:13) and then this one is this recharge into ground water basin so part of it may enter this recharge it may enter into the recharge into the ground water basin in here.

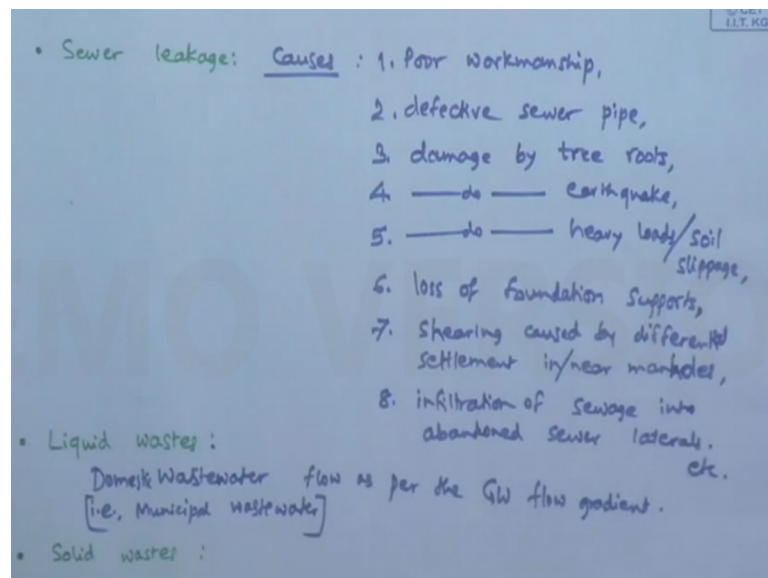
So from this treatment plants or it may go to surface water streams and from this surface water streams. So it may go to this ocean outfalls or part of it may recharge into the ground water basin and then so part of this treatment plant the water which is waste water which go into treatment plant may go to that is reuse of water part of it may be reused after thorough treatment or part of it may result in formation of sledges and again.

So this from the septic tank also so part of it may go to sledges and then so this part of it may go to recharge into ground water basins and these sledges may either go to sanitary and fills or they may go to sledge lagans or they may go to ocean outfalls .So this is the total flow chart of the effects of water when it is used say domestic purpose so whether it is used within a building or in the whether it is used for an indoor purpose or an outdoor purpose.

So this is it may create waste water solid waste or when it is used for outdoor purpose or solid waste recharge into ground water basin or storm water drains like that here so this so in this indoor use of course here we can say this is approximately 50% and then this outdoor use which you say for ground watering or pesticides or car wash or may be swimming pool. So that is also been approximately estimated as 50% of the to the total domestic water use.

So this is the how the when water is used for domestic purpose so this is how these are the various locations where it may move.

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Now let us consider the sewer leakage which is so this sewer leakage this one of the main causes of municipal pollution of ground water pollution due to municipal uses so here this sewer leakage may be due to that is that is say the causes of sewer leakage poor workmanship or it may be defective sewer pipe or it may be due to sewage by tree roots or plant roots or it may be damaged by say earthquake or damage or rupture by heavy loads or soil slippage.

It may also be that is laws of foundation support that cases sewer may show a damage it may show a crack or breakage or it may also be due to shearing caused by differential settlement in man holes near man holes or it may be due to infiltration of sewage into abandoned sewers

sewer laterals so these are the various causes so like poor workmanship the second one is the defective sewer pipe.

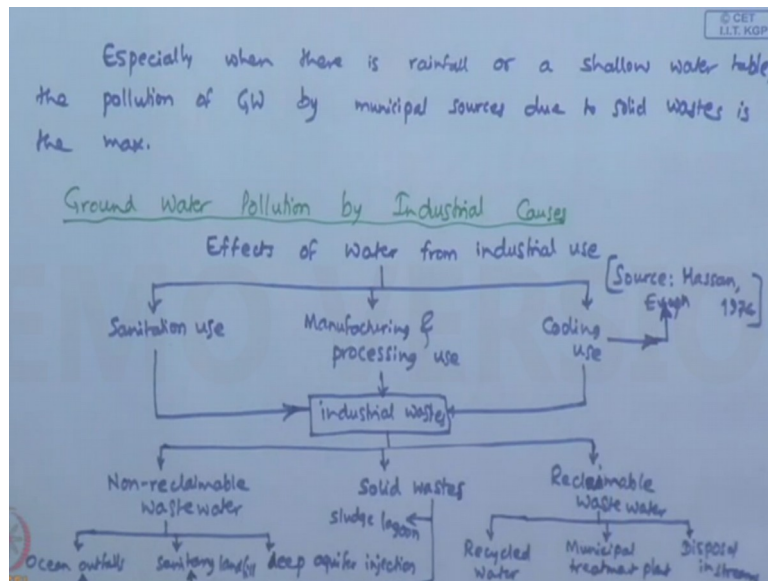
The third one is damage caused by plant roots fourth one is damage caused by earthquake the fifth one is the damage by caused by heavy loads of soil slippage the sixth one is the loss of foundation support the seventh one is the shearing caused by the different settlement near in or near manholes and then this infiltration of sewage into abandoned sewer laterals etc so these are so of the causes of sewer leakage.

Now let us consider the second main type of the municipal the ground water pollution due to the municipal causes that is the liquid waste and you all know that these waste water is having a significant amount of liquid content and this what happens is so this waste water which is generated by these municipal use of water and it results in a significant amount of that is pollution of ground water and these liquid waste move as per the ground water flow directions.

So these are the waste water or we can say the domestic waste water that is the municipal waste water flow as per the gradient the ground water flow gradient. So this leads to this cause the second category of the municipal pollution of ground water and then the last this one is the last cause of the ground water pollution due to municipal sources occurs due to say solid waste.

So here the solid waste are in solid form and then so they are basically dumped into the landfills.

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So this solid waste dumped in landfills cause the leakage into ground water and especially when there is so the especially when there is a rainfall or a shallow water table the pollution of ground water by municipal sources due to solid wastes is the maximum so as long as the that is the there is no rainfall or the water table is it in appropriate depth.

So then so there is there will not be much a fair pollution from the solid waste but as and when there is some amount of rainfall or precipitation or this the wherever there is very shallow ground water table. So this leakage from the landfills so it starts flowing and it causes the ground water pollution so these are so the fewer leakage the liquid waste as well as solid waste.

So they constitute most of the ground water pollution due to municipal causes now let us come to the ground water pollution by industrial causes so here from the same source by Hassan etal let us discuss the effects of water for industrial use. Here in this industrial use again the sources for this also the source is the same publication by Hassan in 1974.

So in which there is a very good this flow chart is given of the effects of water from industrial use. So when the water is used for industrial purposes it may result in mainly three effects the first one is the sanitation use for cleaning purpose and the second one is the manufacturing and processing use then thirdly that is water is used in the industry for cooling purpose or cooling uses.

So here and all this all the three uses result in this what are known as the industrial wastes whether the water used for either the sanitation or cleaning purpose or manufacturing or

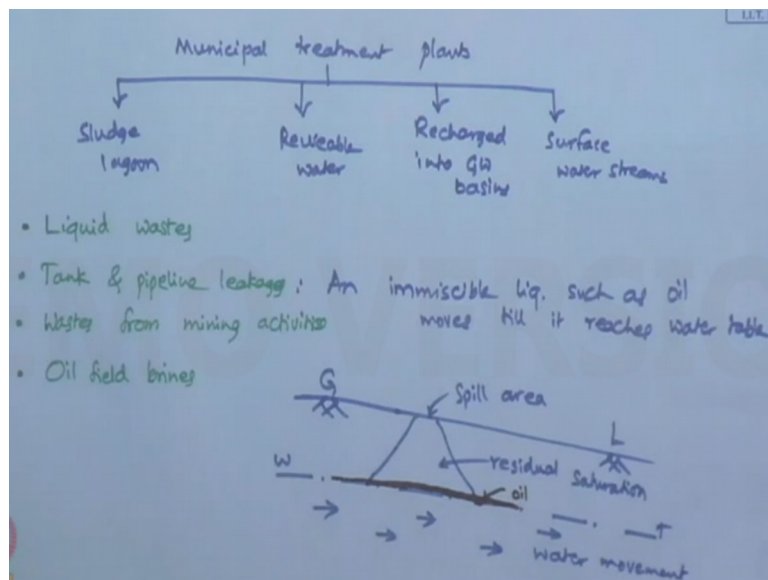


processing purpose or for cooling purpose it all results in the industrial wastes then so these industrial wastes they may be they may result either non reclaimable waste water whose reclamation is almost impossible or economically not feasible or it may result in the industrial wastes.

They may also result in say solid waste such as fliers or other kinds of this solid waste or part it may be reclaimable which can be reclaimed after treatment so that is so this reclaimable waste water and here. So this part of the water which is used for cooling purpose it also evaporates so now this non reclaimable waste water again it has three routes it may either go to ocean outfalls or it may go to a sanitary landfill or it may go to that is deep aquifer injection so this solid waste.

So this also may go to ocean outfall or it may go to a sanitary landfill or it may go to a sludge lagoon and this reclaimable waste water so this is a it may follow any of the three parts the first one is the recycled water again for industrial use then it may go to say municipal treatment plant or it may go to disposal in streams or rivers and then this municipal treatment plants. So from this municipal treatment plants.

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It may go to sludge lagoon or it may go to say reusable water or it may be recharged into ground water basins or lastly it may go to surface water streams .So these are the various types of movement of this one of the industrial of the ground water pollution caused by the industrial uses and again here .So this ground water pollution caused by industrial uses so



they have been mainly categorized as say liquid wastes or tank and pipeline leakages or the wastes from mining activities and here.

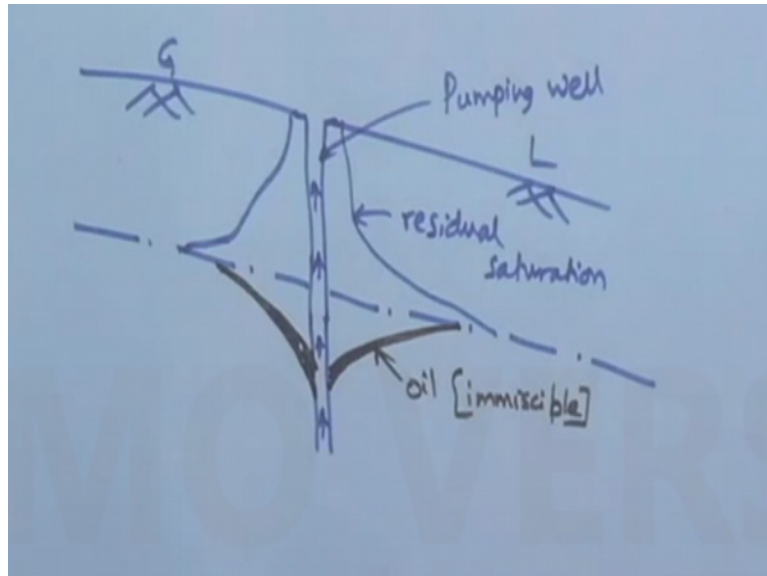
So coming to the liquid waste so these are basically the liquid form of the industrial water. So it flows along with the ground water flow gradient and then it will cause eventually it might cause ground water pollution coming to this tank and pipeline leakages. So here so this is a this happens due to leakages from tanks and pipelines so in this case an immiscible liquid an immiscible liquid such as oil moves till it reaches water table and coming to the waste from mining activities.

So there are multiple ways types of ways are generated from the mining activities so there is a one last category is there that is the oil field brines .So that is the heavy heavily saline pollutions which are released from the oil fields so these are the four categories which result in the ground water pollution due to industrial causes and here so they when you talk of this an immiscible liquid such as an oil.

So here what happen? Says, so if the liquid is a immiscible then it forms a layer. So here so suppose this is the ground surface and then this is a spill area the plume so this the spill area and then so here so this the water table this is the residual saturation and over this so this liquid wastes spreads on top of the water table and then so here if this is the direction of the water movement.

So this is the below the ground water table then so this one the oil also moves along with slowly along with the ground water at the top of the water table and then causes ground water pollution and also suppose if such a case exists of such a case of ground water pollution due to industrial case exist then we can remove this liquid pollutant from this from a pumping well.

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So suppose within this ground water we drill a pumping well this is the water table and the oil which is spilled here which has spread on the ground water and here I can show this is the from the spill area so this is the residual saturation and this is the oil and then so using then and this is the pumping well. So this is possible only when this oil is say immiscible.

So when the oil is immiscible obviously it will spread on the top of the water table and then it can be pumped out so this is the one way and then coming to this oil field brines. So in this case because brine is a very saline solution of waste water saline solution of water so here what happen says It spreads and then so this it will increase the salinity and so therefore it needs to be tackled in a different way so this pumping kind of treatment.

So may not be suitable for that so in the next lecture we will discuss about the ground water pollution by the agricultural sources as well as the miscellaneous sources thank you.