Engineering Hydrology

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Module 1

Lecture 8: Summary

Hello all, welcome back. Today, let us see what are the topics which we have covered in the module 1. We have completed the module 1 in the previous lecture, after completing some numerical examples. Now let me summarize that particular module before moving on to the second module.

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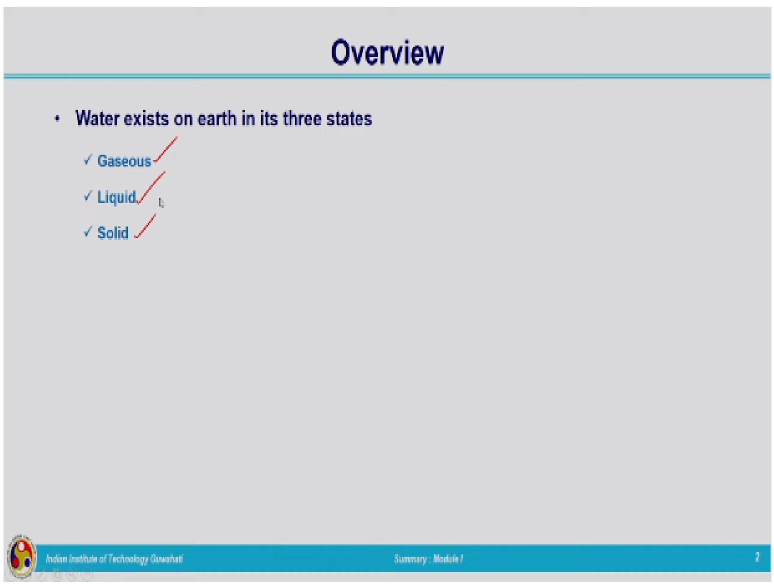

We have seen water is existing on earth in three different forms, that is gaseous form, liquid form and solid form. Three different forms water is existing and the movement of water is very complex. So, we need to understand the dynamics behind this by mathematical equations or formulations. So, for that we were trying to understand the basic concepts related to hydrology in the previous couple of lectures.

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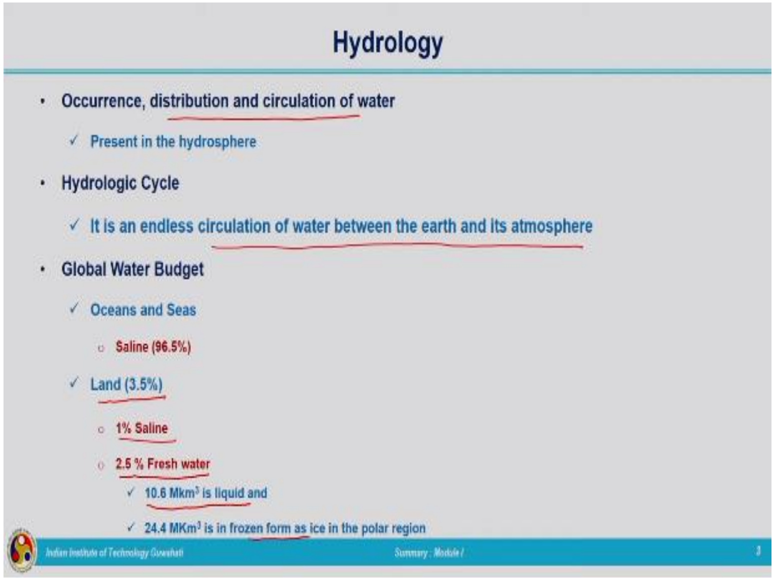

We have started with the definition of hydrology. It is nothing but the occurrence, distribution, and circulation of water. Water is present in the atmosphere that is 1 kilometer into the ground that is in the lithosphere and 15 kilometers into the atmosphere, so that is what is known as the hydrosphere. So water is present in the hydrosphere and maybe in different forms; liquid, solid, or in vapor form.

And after that we have seen hydrologic cycle, how the water transforms from one phase to another. In the atmosphere it is in the vapor form, on the ground surface it is in the water form or in the glaciers it is in the solid form. So, we do not know from where the cycle is starting and we have seen the details about hydrologic cycle as the endless circulation of water between the earth and its atmosphere.

After that for getting a quantitative idea about the total amount of water on earth, we have seen the global water budgeting. We have seen around three-fourth that is 96.5% of water is in oceans and seas, that we know already it is in saline form, it is saline water and remaining 3.5% of water is on earth, and out of that 3.5%, 1% is again saline and remaining 2.5% is fresh water. And out of this 2.5% of fresh water we can make use of around 10.6 Mkm^3 is in the liquid form which can be utilized for our requirements. Remaining water is in the frozen form, in the polar region in the form of glaciers.

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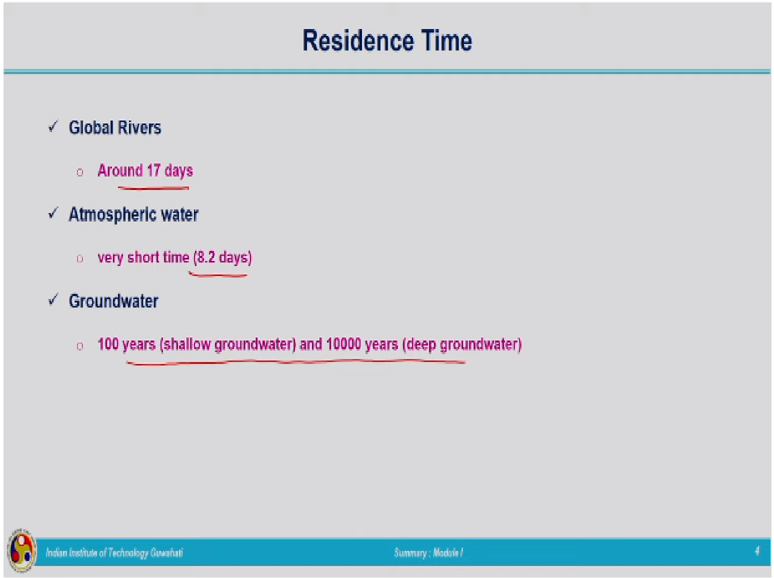

And we have seen a particular term known as residence time. How long a particular water particle will be existing in one phase that is the time taken by a water particle to be in a single state.

In the case of global rivers, it was found out to be 17 days and in the case of atmospheric water it was very short time, that is around 8.2 days only and in the case of ground water it is a long period, a 100 years to 10000 years that depends on the type of the groundwater; shallow groundwater, deep groundwater, so those different terminologies are there. So, depending on the type of ground water storage this will be varying from 100 to 10000 years.

From this we have found that water present in the atmosphere, that is in the vapor form is there only for very few days, that is approximately 8 to 10 days. That is the reason behind why we are not able to forecast for long period of time.

Once we have seen the residence time we have moved to catchment because we could understand that for the quantitative study this water should be applied on a particular area. How that area can be quantified, that was our next concern.

Rainfall is occurring, rainfall in general precipitation is occurring. Where the precipitation is occurring? So, for a particular area this much of rainfall is occurring means whether the entire area is getting the same amount of water or same amount of precipitation or how can it be quantified. For that we have found out the area on which the water is falling and how that water can be quantified, we can calculate based on the concept of catchment.

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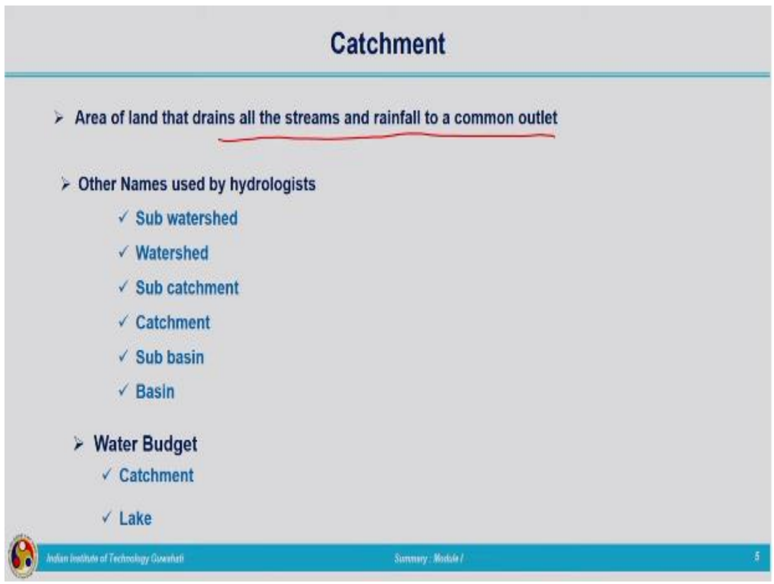

What is catchment? Catchment is the area of land that drains all the streams and rainfall to a common outlet point. We have seen in detail in the lecture related to catchment and catchment was having one outlet point. There all the water which are falling on that particular catchment will be collected at one single outlet point and this catchment is having a well-defined boundary.

And different names have been used by hydrologists for representing the area on which rainfall is falling. Hydrologically, we will be calling it as sub watershed, watershed, sub catchment, catchment, sub basin, basins. But you should understand that all these terminologies are representing the area on which the water is collected at a single outlet point that is meant by these terms. And after seeing the catchment we have seen the water budget equations corresponding to catchment and lake.

Then we could understand that different hydrologic processes are very complex and the movement of water, movement of fluid, it can be in the vapor form, it can be in the liquid form, this is very complex in nature. So for doing the analysis or for doing the quantification of water we need to have some approach to write all these things in mathematical form. So, different approaches are there for studying the fluid flow. I am making use of the term fluid because it incorporates both liquid and vapor, because this study is related to atmospheric hydrology and also surface, subsurface water hydrology. So that is why fluid includes both vapor and liquid.

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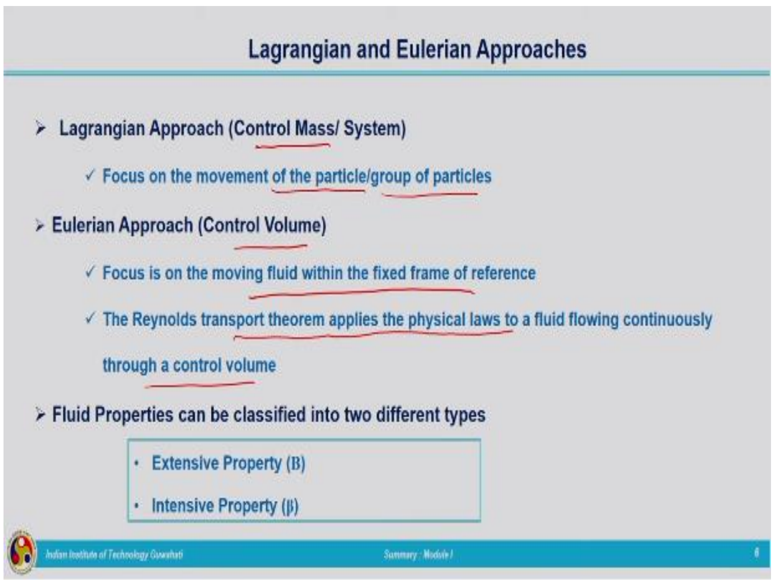

So different approaches are there which are commonly used, one is the Lagrangian approach and second one is the Eulerian approach. We have understood by making use of detailed explanation related to control mass and control volume.

So, in Lagrangian approach our focus is on the movement of the single particle or group of particles. But in the case of Eulerian approach, that is, that concept is also known as control volume approach, in that case our focus is on the moving fluid within the fixed frame of reference, that frame is termed as the control volume. And we are not bothered about the fluid which is outside the control volume, what is coming inside and what is happening within the frame of reference is our major concern, once it has left the control volume we are not bothered about that. That is the difference between the Lagrangian approach and the Eulerian approach. Lagrangian approach focuses on the individual particle or that control mass but in the case of Eulerian approach the mass will be different.

Reynolds Transport Theorem is derived for deriving the physical laws through a control volume. So you can see Reynolds Transport Theorem which is used for deriving the conservation laws is based on the Eulerian approach and it is applicable to the extensive properties.

That is the fluid properties can be classified into two, that is one is the extensive property which depends on the mass of the fluid and the second one is the intensive property which is independent of the mass of the fluid, and we have seen the relationship between these extensive and intensive properties.

Once these concepts that is Lagrangian, Eulerian and the properties related to fluid were clear, we have moved on to the derivation of Reynolds transport theorem. It is nothing but the consistent mechanism for studying the movement of fluid.

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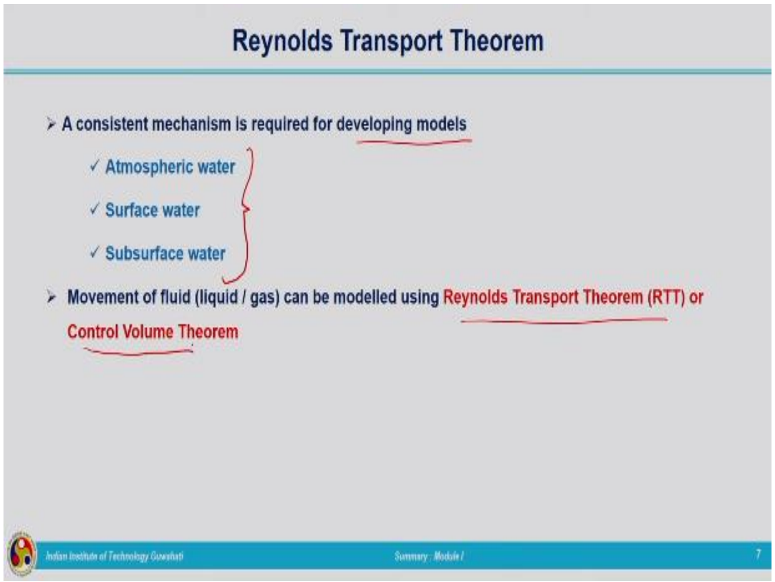

We are having different, that is required for developing the models in the case of atmospheric water, surface water and subsurface water. So movement of the fluid, whenever there is a movement of fluid is coming into picture, for understanding the mechanism, different different mechanisms behind this, we need to have a complicated model which represents the movement of this fluid. So, that can be obtained by means of this Reynolds transport theorem or the control volume theorem.

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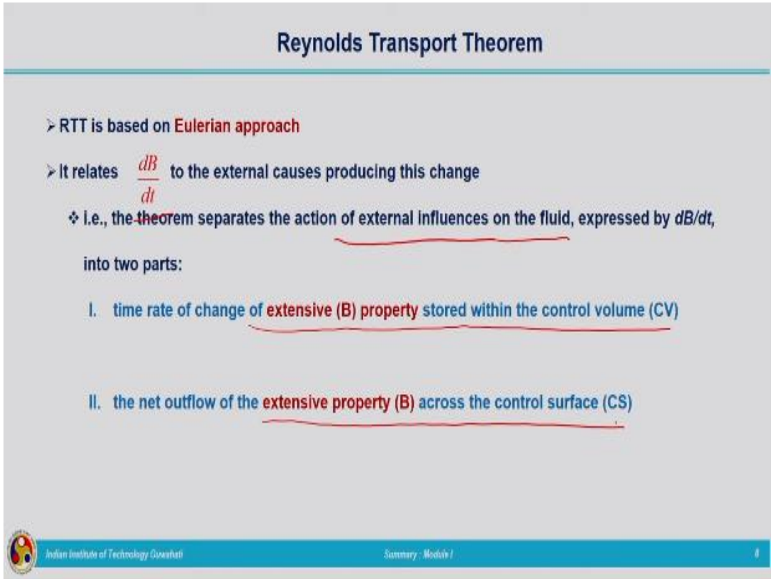

What this RTT was doing? RTT was relating the time rate of change of extensive property of the system to the external causes which is producing that change. So the theorem is separating the action of external influences on the fluid into two parts, that is, we have seen we are having the time rate of change of extensive property (dB/dt) on the left hand side and on the right hand side we were having two parts.

That is what is meant by this first statement, that is it relates $\frac{dB}{dt}$ to the external causes producing this change and it has got two parts, first part is the time rate of change of extensive properties stored within the control volume and second part is the net outflow of the extensive property across the control surface.

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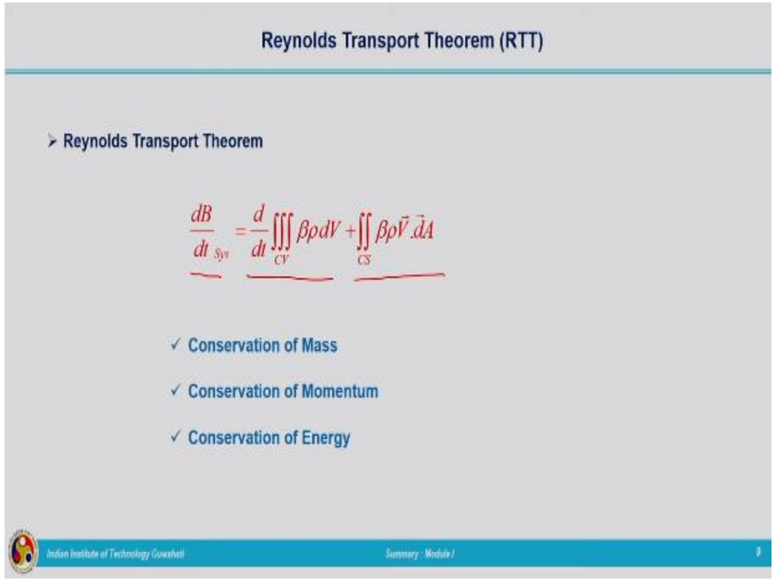

And we have seen the equation, we have derived the mathematical representation regarding the Reynolds transport theorem.

$$\left.\frac{dB}{dt}\right|_{Syt} = \frac{d}{dt}\iiint_{CV} \beta\rho dV + \iint_{CS} \beta\rho \vec{V} \cdot \vec{dA}$$

After deriving the mathematical expression corresponding to Reynolds transport theorem we had used this theorem for deriving our conservation laws, that is the conservation of mass, conservation of momentum and conservation of energy. After that we have seen some numerical examples, two examples for understanding the mass balance equation. Mass balance equation is nothing but our continuity equation.

Two numerical examples we have seen in this module. In the next lecture we will be moving on to the second module related to hydrologic processes, here I am winding up the summary of module 1. Thank you very much.