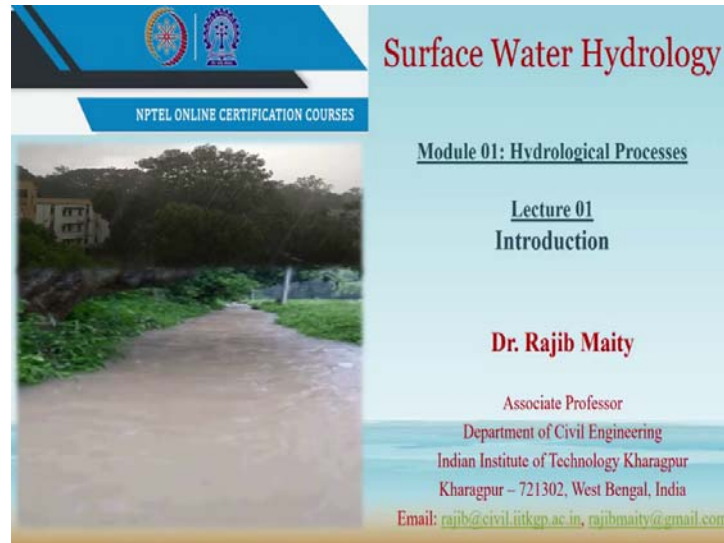


Surface Water Hydrology
Professor Rajib Maity
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Lecture 01
Introduction

Hello students, welcome to this course, Surface Water Hydrology.

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This course is designed in such a way that undergraduate students will find it very useful and the students who want to do some specialization and research on the related fields, related to water and water crisis will find this one useful. This course is also designed in such a way that the practitioners will find it useful to solve some field-scale problems.

In this very first lecture, we will be talking something about the introduction of the entire course, entire course outline and to start with myself, Dr. Rajib Maity. I am from Indian Institute of Technology, Kharagpur, Department of Civil Engineering. You can see my email ID is here, at the end, it is written. So, at any point of time you have any query about the content of this course, you can definitely connect to me.

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Concept Covered

- Introduction to Hydrology and Water Resources
- Distribution of Water on Earth
- Global Hydrological cycle

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So, in this very first lecture, these are the concepts that I will cover. The first one is introduction to hydrology and water resource. This is important! This will help us to develop the motivation why we need this particular course, and in the current context, why this study related to water is very, very important given the context of this climate change that you might be hearing now in different media and resources.

The second thing that I will discuss about is the distribution of water on earth, and of course it will go to the global hydrologic cycle. Some parts will be taken in the next lecture as well.

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Outline

- Overall Outline of the Course
- Introduction
- Distribution of Water on Earth
- Global Hydrological cycle
- Concluding Remarks

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If I come to the outline of this course, so the overall outline of the course that we will be discussed in this very first lecture itself. You will see that there are total three modules: introduction, then analysis, and design. All three things will be covered. I will discuss one by one. Then, I will come to the overall introduction, then as I told in the concept covered, one of the most important thing, how the water is distributed across the earth, and of course, over the time, then the global hydrologic cycle, and finally, the concluding remarks from this discussion.

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Overall Outline of the Course								
Weeks	Lecture Themes	Assignment	Weeks	Lecture Names	Assignment	Weeks	Lecture Names	Assignment
Module 1			Module 2			Module 3		
Hydrological Processes			Hydrologic Analysis			Hydrological Design		
Week 1	Introduction to Hydrological Processes	Online	Week 4	Streamflow measurement: Concept of Streamflow and stage. Measurement of stage in a river, measurement of velocity, different direct and indirect measurement of streamflow: area-velocity method, moving bed method, dilution techniques, flow-measuring structures, slope-area method etc. Stage-discharge relationship-rating curve. Assignment/Quiz	Online	Week 9	Flood Routing: Concept of flood routing and its different types, Basic equations of flood routing, Reservoir routing: modified Puls method, Goodrich method, standard fourth-order Muskingum method, Channel Routing: Muskingum equation, concept of linear reservoir and linear channel, Hydraulic flood routing, Concept of routing in IUH development: Clark's method, Nash curve, etc. Assignment/Quiz	Online
Week 2	Fundamental concept about Hydrology and hydrologic processes, Importance of studying surface water hydrology, Hydrologic cycle and its different components, Surface water resources of India and World, hydrology and climate change, concept of Hydroclimate. Assignment/Quiz	Online	Week 5	Hydrologic Analysis of Run-off: Understanding of different run-off processes, basic concept of Hydrograph, Different catchment characteristics, Rainfall runoff correlation, Flow-duration curve, flow-area curve: calculation of storage volume, concept of environmental flow and its assessment. Assignment/Quiz	Online	Week 10	Hydrologic Frequency Analysis: Basic concepts of probability and statistics, Types of data series and concept of return period, Introduction to frequency analysis, Parametric methods of frequency analysis, Confidence interval and standard error, Various losses in frequency analysis. Assignment/Quiz	Online
Week 3	Hydrologic Analysis of Precipitation: Different forms of precipitation, measurement of precipitation, Estimation of missing data from a long record of precipitation, Concept of rainfall mass curve and Hydrograph, Different methods of estimating mean precipitation over an area: Drych Area Duration (DAD) curves, Maximum Intensity Duration Frequency (IDF) curves, Thiessen Maximum Precipitation (TMP), Rainfall characteristics of India. Assignment/Quiz	Online	Week 6	Analysis of Hydrograph-I: Basics of hydrograph, Base-flow separation techniques, concept of effective rainfall, Direct run-off hydrograph, Introduction to Unit Hydrograph (UH), Application of UH, Derivation of UH. Assignment/Quiz	Online	Week 11	Hydrologic Design-I: Hydrologic design scale and selection of design levels, Risk analysis to determine return period, Concept of reliability and factor of safety Hydroeconomic Analysis, Uncertainty Analysis. Assignment/Quiz	Online
Week 4	Evaporation, different factors controlling evaporation, measuring devices, Different empirical and analytical methods of estimating evaporation, Concept of actual and potential evapotranspiration (AET and PET), measurement of evapotranspiration, Reference crop evapotranspiration, Different empirical formulae to estimate evapotranspiration, Different types of initial loss, Infiltration, infiltration capacity, measurement of infiltration, Different equations to model infiltration aspects, Infiltration indices, α index and ψ index. Assignment/Quiz	Online	Week 7	Analysis of Hydrograph-II: UH of different duration, Uses and Limitations of UH, Synthetic unit hydrograph, Instantaneous Unit Hydrograph (IUH), Assignment/Quiz	Online	Week 12	Hydrologic Design-II: Design Flood, Design Storm, Hydrologic Design of Reservoirs, Determination of Storage Capacity, Design under climate change. Assignment/Quiz	Online
Week 5	Abstraction from Precipitation: Evaporation, different factors controlling evaporation, measuring devices, Different empirical and analytical methods of estimating evaporation, Concept of actual and potential evapotranspiration (AET and PET), measurement of evapotranspiration, Reference crop evapotranspiration, Different empirical formulae to estimate evapotranspiration, Different types of initial loss, Infiltration, infiltration capacity, measurement of infiltration, Different equations to model infiltration aspects, Infiltration indices, α index and ψ index. Assignment/Quiz	Online	Week 8	Floods and Flood Control: Basic concept of flood and its attributes, Catchment Characteristics, Time of concentration, Flood peak-area relationship, Flood control and its status in India. Assignment/Quiz	Online			

Now, this is the overall outline of this course. There are mainly three modules are there. In the first module, we will discuss about hydrological processes. In the second module, which is one of the major components of this course that is hydrological analysis and the third one deals with the hydrological design. So, as you can see that it goes in a flow where we need the background knowledge to proceed one after another.

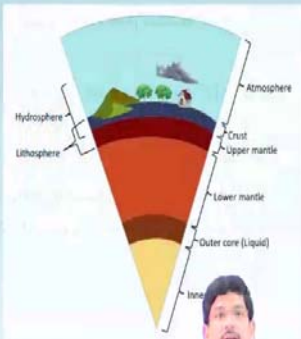
So, in the hydrological processes, in the very first module, we will be discussing mainly: what is hydrological cycle? And, most importantly, how this is creating the backbone for the surface water hydrology. And, why and what are the recent changes with respect to the climate change. These are the major focuses that will be included in the first module.

Second module, as you can see here, it spans from week 2 to week 9, where different analyses related to surface water hydrology will be discussed, and this knowledge will be utilized in the third module, where we will be discussing some of the applications in hydrological design.

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Introduction: What is Hydrology?

- Water exists on earth in an imaginary space called the hydrosphere which extends about 15 km up into the atmosphere and about 1 km down into the lithosphere, the crust of the earth. Water circulates in the hydrosphere through the maze of paths constituting the hydrologic cycle, which is the central focus of hydrology.
- Before going deep into hydrology, let us first have a general discussion on water and its different aspects on earth.



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Next, as you may be knowing, that water exists on the earth in a space with uncertain varying boundaries. What I mean is that it can be below the surface and it can be the above the surface also. This is almost about, say 15 km above the surface in the atmosphere and almost about one km below the ground. This entire area is known as hydrosphere. There are different paths and processes through which the hydrologic cycle takes place which, of course, as I told you, is the central focus of the hydrological science.


So, before we go deep into the hydrology, let us first have a general discussion on water and its different aspects on the earth.

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Introduction: Water Resources on Earth

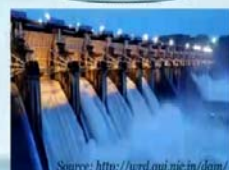
- Water is one of the primary reasons behind life on our Earth. It is the most abundant substance on Earth and constitutes the principal portion in any living thing.
- It also has played a key role in the progress of human civilization from the time immemorial. The Indus Valley Civilization (along the Indus), Ancient Egypt (along the Nile), Mesopotamia (along the Tigris and Euphrates rivers), and Chinese civilization (along the Yellow River) are some prominent examples of ancient river-dependent civilizations on Earth.

Beautiful




Source: insideclimatenews.org


Powerful



Source: <http://www.guj.nic.in/dam/>

Destructive





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Water as a resource on the earth, as you might be knowing already, is one of the primary reason behind the life on the earth. It is the most abundant substance on the earth and constitutes the principal portion in any living thing. So, it has also played the key role in the progress of the human civilization from the ancient time. You might be knowing about Indus valley civilization or ancient Egypt or Mesopotamia, the Chinese civilization. All these were along some big river basins or river network, and these are some of the prominent examples of the ancient river dependent civilization on the earth.

So, this pictorial presentation, you can see that sometimes we find water is very '*beautiful*'. As you can see next, in the diagram, it is really '*powerful*'. It helps us to generate some power, and which is definitely one of the sources of renewable energy. You may have heard this term. Finally, sometimes it can be '*destructive*' also that many of us have seen or heard from different news and media, or even experienced as well. So, it can be *beautiful*, it can be *powerful*, and it can be *destructive*.

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When Water is a Blessing

- Importance of water on earth can be understood considering any of the aforementioned ancient human civilization. Contribution of water towards their development was manifold, e.g.

Source of Drinking water

Supply of Fertilite Sediments

Easy mode of Transportation

Industrial Development

Hydropower Generation

Agricultural productivity

Thus, Water is always considered as a Resource

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Thus, water it can be a *blessing*, or it can be a *curse* both. Considering water as a blessing, the importance of the water on the earth can be understood from any of the aforementioned ancient human civilizations. This is why the human beings thought that their civilization should be in and around a river basin. The first thing is that it serves as the source of the drinking water. It supplies the fertile sediments when it is considered for the agricultural productivity. During the flood time, lots of sediment comes and this is highly fertile.

River networks help in transportation. Then, it is essential for industrial development. There are many industries developed on the bank of the river to meet their need for water. Next, there is hydropower generation also. So, this is just an indicative list. There are many more that you can imagine when water can be considered as a blessing. So, it is truly speaking that the water is always considered as a resource that makes the term the water resource.

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When Water is a Curse

- There are many water related problems. Some of these problems can be natural (e.g., Floods, Droughts etc.), and some of these issues are direct consequences of human influence (e.g., Water pollution, Water-borne diseases etc.).

Drought	Flood	Water pollution	Water-borne diseases
<ul style="list-style-type: none"> shortage of water and food degradation of public health loss of lives From 1970 to 2012, drought caused almost 680000 deaths (WMO, 2014) 	<ul style="list-style-type: none"> plenty of water logging and overflow of water drinking water get polluted can destroy buildings, bridges can ruin a productive agricultural field. Loss of lives and cattles 	<ul style="list-style-type: none"> death of aquatic animals imbalance in ecosystem may spread water-borne diseases aesthetically unpleasing 	<ul style="list-style-type: none"> industrial waste, human waste, garbage, untreated sewage, chemical effluents, etc. leads to waterborne diseases like cholera and typhoid fever, diarrhoea, dysentery, polio and meningitis.

Is there any human influences behind so called natural problems, such as Floods, Droughts?

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But, at the same time, it also creates some sort of *curse*, as there are many water related problems that we know. Some of such problems can be natural, like the floods and droughts, and some of these issues are the direct consequences of the human influences such as water pollution, water-borne diseases etc. You can see some of the glimpse of the snapshots of drought, flood, then water pollution, water-borne diseases.

The droughts, as you know, cause the shortage of the water and food. It causes a degradation of the public health. It causes loss of the life too. From 1972 to 2012, it caused almost about 6,80,000 deaths as per the WMO record in 2014.

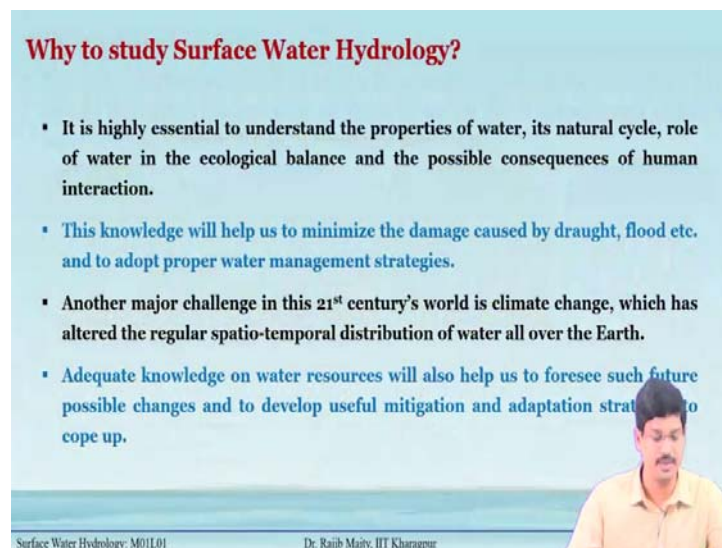
Regarding flood, it is opposite of the drought. During the flood, there is a plenty of waterlogging and the overflow of the water. Drinking water gets polluted. It can destroy the buildings/bridges, ruin the productive agricultural field, cause the loss of lives and cattle.

Considering water pollution, there are deaths of aquatic life, imbalance in the ecosystem. It may spread water-borne diseases. It is of course aesthetically unpleasing. Moreover, water-borne diseases, as we know, caused due to the industrial waste and human waste, garbage,

untreated sewage, chemical effluents. These sometimes are released without any basic treatment to the nearby surface water sources, like rivers, lakes. It causes different water-borne disease like cholera, typhoid, then diarrhoea, dysentery, polio and so on and so forth.

However, when we start, I told there are few things are natural and few things are due to the direct influence of the human beings. But the question is that: Is there any human influence behind the so called natural problems, such as floods and droughts? Because this is very recent as compared to all other things that I discussed from the ancient era. Very recently, our realization is that even for the floods and droughts, there are some indirect influences that human beings are creating, and this is basically the manifestation of the climate change that we will take up time to time during this course.

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Why to study Surface Water Hydrology?

- It is highly essential to understand the properties of water, its natural cycle, role of water in the ecological balance and the possible consequences of human interaction.
- This knowledge will help us to minimize the damage caused by draught, flood etc. and to adopt proper water management strategies.
- Another major challenge in this 21st century's world is climate change, which has altered the regular spatio-temporal distribution of water all over the Earth.
- Adequate knowledge on water resources will also help us to foresee such future possible changes and to develop useful mitigation and adaptation strategies to cope up.

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So, this basic introduction forms the motivation why to study this particular course, *surface water hydrology*. As you know, it is highly essential to understand the properties of the water, its natural cycle, its role in the ecological balance, and the possible consequences on the human interaction.

Secondly, this knowledge will help us to minimize the damage caused by the droughts and floods etc., and to adopt proper water management strategies, if we know the different processes that is involved within it.

Another major challenge in the 21st century, as I mentioned, is the climate change, which has altered the regular spatio-temporal distribution of the water all across the earth. That means

whatever we know, in general, about its distribution, now, impact of climate change has caused some sort of redistribution of water resources over space and time. So, that is very much essential information for us to rethink about the management of the water that is available to us. Last but not least, the adequate knowledge on the water resources will also help us to foresee such future possible changes and to develop the useful mitigation and adaptation strategies to cope up.

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Why to study Surface water hydrology?

In a nutshell, practical applications of hydrology can be found in the following areas:

- design and operation of hydraulic structures
- water supply networks
- wastewater treatment and disposal
- Irrigation channels
- drainage system
- hydropower generation
- Flood/ drought control
- navigation
- erosion and sediment control
- salinity control
- pollution abatement
- recreational use of water
- fish and wildlife protection
- Climate change adaptation and mitigation

Before starting further technological details about surface water hydrology in the subsequent weeks, this week we will build some preliminary concept about distribution of water resources on earth, hydrological cycle, surface water resources of India, and finally some discussions on possible impacts of changing climate on it.

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Coming to the next one, why to study this surface water hydrology? In a nutshell, there are different practical applications of hydrology that can be found in many areas. Some of the areas are listed here. It starts from design and operation of the hydraulic structures, water supply networks, wastewater treatment and disposal, irrigation channels, drainage system, hydropower generation, flood and drought control, then navigation, erosion and sediment control, salinity control, pollution abatement, recreational use of water, fish and wildlife protection, and finally the climate change adaptation and mitigation.

So, before proceeding further on the details about the surface water hydrology in the subsequent weeks, this week we will build some preliminary concepts about the distribution of the water resource on the earth, hydrological cycle, surface water resource of India, and finally some discussions on the possible impact of changing climate on it. So, overall, this is how the first week is designed.

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Summary

- In this very first lecture, overall outline of the course is discussed.
- Different practical applications of hydrology in the various fields of applications are discussed.
- Importance of Surface Water Hydrology in the context of its impact on society and ecosystem is stressed upon.
- An idea about possible adverse impacts of changing climate on water resources is conveyed. It will be discussed again in details later.

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Coming to the summary of this very first lecture, this lecture is basically covered the overall outline of the course on how we will proceed. Secondly, the different practical applications, particularly for the practitioners, those who are working in the different field related problems related to hydrology, in the various fields of applications. These are just mentioned.

The importance of the surface water hydrology in the context of its impact on society and ecosystem is stressed upon, and an idea about the possible adverse impacts of changing climate on the water resource is conveyed. It will be of course discussed again in details later in this course. Thank you.