Principles of Water Resources Engineering - Surface and Ground Water Resources

Water in our planet is available in the atmosphere, the oceans, on land and within the soil and fractured rock of the earth's crust Water molecules from one location to another are driven by the solar energy. Moisture circulates from the earth into the atmosphere through evaporation and then back into the earth as precipitation. In going through this process, called the Hydrologic Cycle (Figure 1), water is conserved — that is, it is neither created nor destroyed. "The rivers... all discharge their waters into the sea. They lead from sea to sea, the clouds raise them to the sky as vapour and release them in the form of rain..." The earth's total water content in the hydrologic cycle is not equally distributed.

Total global water content = Fresh water 2.5%; Saline water in Oceans 97.5%

The oceans are the largest reservoirs of water, but since it is saline it is not readily usable for requirements of human survival. The freshwater content is just a fraction of the total water available (Figure 3).

Global fresh water distribution= Lakes, Rivers, and Soil Moisture 0.4%
Ground Water 25.5 % Ice caps and Glaciers 74% Again, the fresh water distribution is highly uneven, with most of the water locked in frozen polar ice caps.

The hydrologic cycle consists of four key components 1 . Precipitation; 2. Runoff 3. Storage 4. Evapotranspiration

1.1.1 Precipitation: precipitation occurs when atmospheric moisture becomes too great to remain suspended in clouds. It denotes all forms of water that reach the earth from the atmosphere, the usual forms being rainfall, snowfall, hail, frost and dew. Once it reaches the earth's surface, precipitation can become surface water runoff, surface water storage, glacial ice, water for plants, groundwater, or may evaporate and return immediately to the atmosphere. Ocean evaporation is the greatest source (about 90%) of precipitation.

Rainfall is the predominant form of precipitation and its distribution over the world and within a country. India has a typical monsoon climate. At this time, the surface winds undergo a complete reversal from January to July, and cause two types of monsoon. In winter dry and cold air from land in the northern latitudes flows southwest (northeast monsoon), while in summer warm and humid air originates over the ocean and flows in the opposite direction (southwest monsoon), accounting for some 70 to 95 percent of the annual rainfall. The average annual rainfall is estimated as 1170 mm over the country, but varies significantly from place to place. In the northwest desert of Rajasthan, the average annual rainfall is lower than 150 mm/year. In the broad belt extending from Madhya Pradesh up to Tamil Nadu, through Maharastra, parts of Andhra Pradesh and Karnataka, the average annual rainfall is generally lower than 500 mm/year. At the other extreme, more than 10000 mm of rainfall occurs in some portion of the Khasi Hills in the northeast of the country in a short period of four months. In other parts of the northeast (Assam, Arunachal Pradesh, Mizoram, etc.,) west coast and in sub-Himalayan West Bengal the average annual rainfall is about 2500 mm. Except in the northwest of India, inter annual variability of rainfall in relatively low. The main areas affected by severe droughts are Rajasthan, Gujarat (Kutch and Saurashtra).

The year can be divided into four seasons: The winter or northeast monsoon season from January to February. The hot season from March to May. The summer or south west monsoon from June to September. The post monsoon season from October to December.

1.1.2 Runoff: Runoff is the water that flows across the land surface after a storm event. As rain falls over land, part of that gets infiltrated the surface as overland flow. As the flow bears down, it notches out rills and gullies which combine to form channels. These combine further to form streams and rivers.

The geographical area which contributes to the flow of a river is called a river or a watershed.

Indus, Ganges, Brahmaputra, Krishna , Godavari, Mahanandi, Sabarmati, Tapi, Brahmani-Baitarani, Narmada, Pennar, Mahi are important river basins of india.

1.1.3 Storage: portion of the precipitation falling on land surface which does not flow out as runoff gets stored as either as surface water bodies like Lakes, Reservoirs and Wetlands or as sub surface water body, usually called Ground water. Ground water storage is the water infiltrating through the soil cover of a land surface and traveling further to reach the huge body of water underground. The amount of ground water storage is much greater than that of lakes and rivers. However, it is not possible to extract the entire groundwater by practicable means. It is interesting to note that the groundwater also is in a state of continuous movement flowing from regions of higher potential to lower. The rate of movement, however, is exceptionally small compared to the surface water movement.

Lakes: Large, naturally occurring inland body of water
Reservoirs: Artificial or natural inland body of water used to store water to meet various demands.
Wet Lands: Natural or artificial areas of shallow water or saturated soils that contain or could support water loving plants.

1.1.4 Evapotranspiration: Evapotranspiration is actually the combination of two terms evaporation and transpiration. The evaporation is the process of liquid converting into vapour, through wind action and solar radiation and returning to the atmosphere. Evaporation is the cause of loss of water from open bodies of water, such as lakes, rivers, the oceans and the land surface. ocean evaporation provides approximately 90 percent of the earth's precipitation. However, living near an ocean does not necessarily imply more rainfall as can be noted from the great difference in the amount of rain received between the east and west coasts of India.
Transpiration is the process by which water molecules leaves the body of a living plant and escapes to the atmosphere. The water is drawn up by the plant root system and part of that is lost through the tissues of plant leaf (through the
stomata). In areas of abundant rainfall, transpiration is fairly constant with variations occurring primarily in the length of each plants growing season. However, transpiration in dry areas varies greatly with the root depth. Evapotranspiration, therefore, includes all evaporation from water and land surfaces, as well as transpiration from plants.

1.1.5 Water resources potential
1.1.5.1 Surface water potential: The average annual surface water flows in India has been estimated as 1869 cubic km. This is the utilizable surface water potential in India. But the amount
of water that can be actually put to beneficial use is much less due to severe limitations posed by Physiography, topography, inter state issues and the present state of technology to harness water resources economically. The recent estimates made by the Central Water Commission, indicate that the water resources is utilizable through construction of structures is about 690 cubic km (about 36% of the total). One reason for this vast difference is that not only does the whole rainfall occur in about four months a year but the spatial and temporal distribution of rainfall is too uneven due to which the annual average has very little significance for all practical purposes.
Monsoon rain is the main source of fresh water with 76% of the rainfall occurring between June and September under the influence of the southwest monsoon.
The average annual precipitation in volumetric terms is 4000 cubic km. The average annual surface flow out of this is 1869 cubic km, the rest being lost in infiltration and evaporation.

1.1.5.2 Ground water potential: The potential of dynamic or rechargeable ground water resources of our country has been estimated by the Central Ground Water Board to be about 432 cubic km.
Ground water recharge is principally governed by the intensity of rainfall as also the soil and aquifer conditions. This is a dynamic resource and is replenished every year from natural precipitation, seepage from surface water bodies and conveyance systems return flow from irrigation water, etc.

Utilizable surface water potential: This is the amount of water that can be purpose fully used, without any wastage to the sea, if water storage and conveyance structures like dams, barrages, canals, etc. are suitably built at requisite sites.

Central Water Commission: Central Water Commission is an attached office of Ministry of Water Resources with Head Quarters at New Delhi.The commission is charged with the general responsibility of initiating, coordinating and furthering, in consultation with the State Governments concerned, schemes for control, conservation and utilization of water resources throughout the country, for purpose of flood control, irrigation, navigation, drinking water supply and water power development.

Central Ground Water Board: It is responsible for carrying out nation-wide surveys and assessment of groundwater resources and guiding the states appropriately in scientific and technical matters relating to ground water. The Central Ground Water Board has generated valuable scientific and technical data through regional hydro geological surveys, groundwater exploration, resource and water quality monitoring and research and development. It assists the States in developing broad policy guidelines for development and management of groundwater resources including their conservation, augmentation and protection from pollution, regulation of extraction and conjunctive use of surface water and ground water resources. The Central Ground Water Board organizes Mass Awareness Programmes to create awareness on various aspects of groundwater investigation, exploration, development and management.

Ground water recharge: Some of the water that precipitates, flows on ground surface or seeps through soil first, then flows laterally and some continues to percolate deeper into the soil. This body of water will eventually reach a saturated zone and replenish or recharge groundwater supply. In other words, the recuperation of groundwater is called the groundwater recharge which is done to increase the groundwater table elevation. This can be done by many artificial techniques, say, by constructing a detention dam called a water spreading dam or a dike, to store the flood waters and allow for subsequent seepage of water into the soil, so as to increase the groundwater table. It can also be done by the method of rainwater harvesting in small scale, etc.

1.1.6 Land and water resources of India

The two main sources of water in India are rainfall and the snowmelt of glaciers in the Himalayas. snow and glaciers are poor producers of fresh water, they are good distributors as they yield at the time of need, in the hot season.

1. Internal Renewable Water Resources: Internal Renewable Water Resources are the surface water produced internally, i.e., within a country. It is that part of the water resources generated from endogenous precipitation. It is the sum of the surface runoff and groundwater recharge occurring inside the countries borders.

Surface water produced internally: Total surface water produced internally includes the average annual flow of rivers generated from endogenous precipitation (precipitation occurring within a country's borders). It is the amount of water produced within the boundary of a country, due to precipitation.

Groundwater recharge: The recuperation of groundwater is called the groundwater recharge. This is requisite to increase the groundwater table elevation. This can be done by many artificial techniques, say, by constructing a detention dam called a water spreading dam or a dike, to store the flood waters and allow for subsequent seepage of water into the soil, so as to increase the groundwater table. It can also be done by the method of rainwater harvesting in small scale, even at individual houses.
The groundwater recharge volume is 418.5 cubic km and the per capita annual volume of groundwater recharge is 412.9 cubic m per person.

. Overlap: It is the amount of water quantity, coinciding between the surface

water produced internally and the ground water produced internally within a country, in the calculation of the Total Internal Renewable Water Resources of the country. Hence, Overlap = Total |RWR— (Surface water produced internally + ground water produced internally). The overlap for Indian water resources is 380 cubic km.

Total internal Renewable Water Resources: The Total Internal Renewable Water Resources are the sum of IRWR and incoming flow originating outside the countries borders. The total renewable water resources of India are 1260.5 cubic.km

Per capita Internal Renewable Water Resources: The Per capita annual average of Internal Renewable Water Resources is the amount of average IRWR, per capita, per annum.

Annual water withdrawal: The total amount of water withdrawn from the water resources of the country is termed the annual water withdrawal. In India, it amounts 500000 to million cubic m.

Per capita annual water withdrawal: It is the amount of water withdrawn from the water resources of the country, for various purposes. The per capita annual total water withdrawal in India is 592 cubic m per person.

1.1.8 Development of water resources

Due to its multiple benefits and the problems created by its excesses, shortages and quality deterioration, water as a resource requires special attention. India has about 16% of the world population as compared to only 4% of the average annual runoff in the rivers.

Some of the salient features of the National Water Policy (2002) are as follows:

0 Since the distribution of water is spatially uneven, for water scarce areas, local technologies like rain water harvesting in the domestic or community level has to be implemented.

o Technology for/Artificial recharge of water has also to be bettered. o Desalination methods may be considered for water supply to coastal towns.

1.1.9 Present water utilization in India: Irrigation uses is 84 percent of total water use in our country. This is much higher than the world’s average, which is about 65 percent. The term irrigation is defined as the artificial method of applying water to crops.

Irrigation increases crop yield and the amount of land that can be productively farmed, stabilizes productivity, facilitates a greater diversity of crops, increases farm income and contributes to regional development.

1.1.10 Need for future development of water resources

The present food grain availability of around 525 grams per capita per day is also presumed to rise to about 650 grams, considering better socio economic lifestyle

Consumptive use: Consumptive use is the amount of water lost in evapo-transpiration from vegetation and its surrounding land to the atmosphere, inclusive of the water used by the plants for building their tissues and to carry on with their metabolic processes. Evapo-transpiration is the total water lost to the atmosphere from the vegetative cover on the land, along with the water lost from the surrounding water body or land mass.

1.1.11 Sustainable water utilisation: The quality of water is being increasingly threatened by pollutant load, which is on the rise as a consequence of rising population, urbanization, industrialization, increased use of agricultural chemicals, etc. Both the surface and ground water have gradually increased in contamination level. It is difficult to restore ground water quality once the aquifer is contaminated. Ground water contamination occurs due to human interference and also natural factors .