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CHAPTER

Water Resources

LEARNING OBJECTIVES

Introduction • Types of Water Sources and their Uses • Available Water for Human Use-The Fresh Water • Fresh Water Requirements in India • India's Fresh Water Budget • Indian Riverine System • Interlinking of Indian Rivers: Projected Gains in v/s Hydrological Suicide • Use and Over-utilisation of Surface and Ground Water • Floods • Drought,Conflicts Over Water • Dams: Benefits and Problems.

Introduction

Water is a wondrous gift of nature. Literally, water is elixir of life. It is the only inorganic liquid that occurs naturally on this earth. Water is also the only chemical compound on this planet that exists in all three physical states-solid (ice), liquid and gaseous (vapour). Sanskrit equivalent of water is "jeevan" or life. Hydrosphere is the water domain. A, once abundant resource that existed in oceans, seas, rivers, streams, lakes, reservoirs, glaciers, polar ice-caps, shallow ground water bodies and as ground water, is increasingly being wasted, misused or polluted.

People say that world is moving towards water wars. World is facing an impending crisis of water most visible in many countries. Fresh water resources of the world are finite in nature and at the same time only a small fraction of it is accessible and readily usable to human and ecological systems. The hydrological cycle controls the temporal and spatial distribution of the renewable fresh water in the form of evapotranspirations, precipitation and run off. Climatic factors and climatic changes further complicate the predictability of this distribution, particularly in heavily populated areas of the world. The total stock of ocean water and fresh water on this earth has been fairly constant throughout geological history but the ratio between ocean water and fresh water always changed according to climatic changes, mostly brought about by human activities. Evidently, global climate is getting warmer and sea level, during the last decades, is rising slowly.

Despite the fact that most of India is blessed with abundant monsoon rains, its water supplies are stranded by unchecked population growth and rapid developments most visible in many of its cities. Water crisis can also be seen in its rural areas but the reasons are different. India and China are considered among the water hotspots, primarily because of their large populations that have to be provided with drinking water. By 1994, there were more than 55,000 villages in India which did not have a source of drinking water. Apart from increasing population, steady deterioration, disuse, and disappearance of traditional tanks, ponds and wells, are the other causes of water crisis in India. In recent years the problem got aggravated due to extraction of ground water using bore well operarted by electric, diesal or petrol pumps. It is estimated that the water extraction rate is already twice the recharge rate.

Wisely used, water means harvests, health and prosperity for peoples and the nations on the earth. When badly managed or out of control, water contributes to economic underdevelopment, poverty, disease, flooding, drought, soil erosion, salinisation, water logging, silting, environmental degradation and human conflict. At the end of century the world faced a number of challenges affecting the availability, accessibility, use and sustainability of its fresh water resources. Consequently this could adversely impact upon the needs of present and future generation. Equally critical are the needs of ecosystems that depend on fresh water for their existence. The effective management of world's water resources will contribute to the strenghtening of peace, security, cooperation and friendly relations among nations. Because water is most vital of all natural resources, it has the power to promote economic and social advancement of all peoples.

Types of Water Sources and their Uses

In nature, water occurs in oceans, on the land, underground, in the atmosphere and in the biomass. Of the total volume of water available on this earth, 97 per cent is in the vast oceans, 2 per cent is locked in the form of ice-sheets and only less than 1 per cent is available as fresh water for which all people, animals and plants compete.

Water in the Oceans. Oceans contain 97 per cent of water but their water contains high concentration (3.5 per cent) of salts in solution. The main source of salinity of the oceans is due to falling of rivers that carry with them billions of tons of dissolved minerals every year.

Most of the ocean water is contained in Pacific Ocean, covering about one-third of earth's surface. It is deepest of all oceans and its area exceeds the total land area of the earth. Atlantic Ocean is roughly half of the size of the Pacific Ocean. The Indian Ocean, with an average depth of 4000

metres, is smaller than Atlantic Ocean. The Arctic Ocean, surrounding North Pole, is completely frozen and unnavigable.

Salinity and temperature are two important features of ocean water which determine the movement of large masses of water and their characteristics and also the type of marine flora and fauna. The huge amount of the salinity in ocean water makes it uneconomical to make it potable, *i.e.*, fit for drinking and cooking. But, at places where sea water is the only source available, the potable water is obtained by desalinising or demineralising the sea water, as is done in ships on the high seas.

Water on the Land Surface. Water falling in the form of precipitation runs down the slope of land in the form of lotic water bodies (in which water flows) like rivers, streams etc. or lentic water bodies (in which water remains stagnant) such as lakes, reservoirs, ponds etc. or may get stored on the land in the form of ice-sheets. Water is also used by plants, animals and man in the biosphere. Some water percolates and is trapped underground below the land surface. Surface water available on the land is most accessible source of water for human needs. The amount of surface water in a region depends on total precipitation and its seasonal distribution and also on the nature of rocks and soils of which land is made.

In India, according to an estimate, to 1,150 cubic km of fresh water, which appears as surface water, may be added 200 cubic km of surface flow which comes from outside the country. The surface flow is further enhanced by addition of about 450 cubic km of fresh water from ground water flow while about 50 cubic km. are added as run off from irrigated areas. The surface also loses about 50 cubic km of its water which percolates down to the ground water resources. The total surface flow per year is about 1,800 cubic km. which is distributed among a number of river basins. Various surface water sources are:

1. **Rivers and Streams:** The precipitation, that does not evaporates or infiltrates, runs off over the ground surface in the form of streams and rivers which flow towards the sea. Rivers and streams are the major source of water supply. They have long been used for discharging waters. Most of the civilisations have grown and flourished on the banks of the rivers. In our country most important cities and religious places are located near rivers. Their water is generally more variable in quality. It is less satisfactory than water from lakes and impounded reservoirs. The water quality of rivers depends on various factors such as the characteristics and the area of watershed, geology, topology, seasonal variations, weather conditions, disposal of sewage, pollutants, agricultural washouts, industrial effluents etc. Most of Indian rivers especially Ganga and Yamuna, have become polluted to such an extent that their water has become unfit for human use.

2. **Natural Lakes and Ponds:** Natural lakes are the inland depressions that hold fresh water for long periods. Ponds are generally small and permanent or temporary fresh water bodies. The water of lakes and ponds is much more accessible than the ground water. They are the important sources of water supply in limited quantities. Their water is more uniform in quality than water from rivers and streams. Unfortunately most of Indian lakes are shrinking due to man caused pollution and ponds are disappearing due to increased land demand for agriculture or housing to accommodate huge population.

3. **Artificial Impounding Reservoirs:** Artificial impounding reservoirs are formed by constructing hydraulic structures such as dams across river valleys. Deeper and narrower valleys are most suitable for construction of dams. Their water is much more accessible than ground water as their water quality is similar to that of natural lakes and ponds. They have played a crucial role in improving the economy of our county by providing enough water for irrigation and domestic use and generating hydro-power but they have left a serious problem of resettlement and rehabilitation of oustees from the areas where dams are constructed.

Most surface water originates directly from the precipitation or snowfall but it is also contributed by ground water from springs and seeps. A large amount of surface water is also contributed by melting of glaciers due to global warming.

GROUND WATER

The rainwater and water from melted ice that neither runs off along the surface nor evaporates but reaches under the surface of the land through pores and cracks, is called ground or underground water. Some ground water may originate from the streams rising from the molten rock materials deep within the earth. Springs owe their existence due to flow of ground water. Although ground water occurs in small amounts everywhere in the soil but great amount of it reaches the sea after moving through underground channels, becoming a part of hydrological cycle.

About 9.86 per cent of the total freshwater resources is in the form of ground water. Till sometimes back, ground water was considered to be pure but now many ground water aquifers are being contaminated by leaches from sanitary landfills and dumping of many undesirable substances.

A layer of sediment or rock that is highly permeable and contains water is, called aquifer. Sand and gravel layers are good aquifers while clay and crystalline rocks, because of low permeability, are not so. Aquifers may be

unconfined or confined. Unconfined aquifers are overlaid by permeable earth materials and are recharged by water seeping down from above in the form of precipitation and snow melt. Confined aquifers are sandwitched between two impermeable layers of rocks or sediments and are recharged only in those areas where the aquifer interacts the land surface. Sometimes their recharge is hundreds of kilometers away from the location of the well. The two aquifers are shown in the ground water system (fig. 4.1). The Ground water is not static but it moves. The rate of its movement is very slow, *i.e.*, about one meter or so in a year.

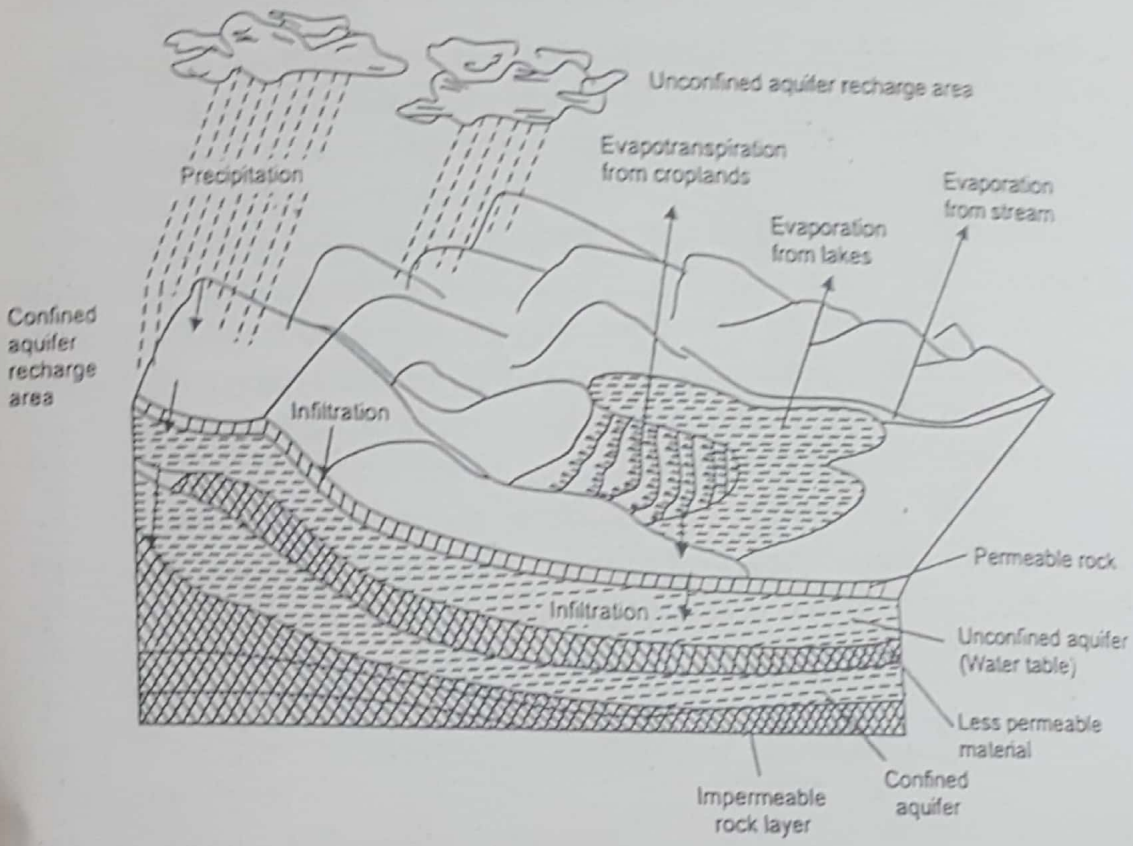

Fig. 4.1. Ground water system.

Ground water is one of the largest fresh water resources, next to surface water, for agricultural and domestic use in many areas of the world, particularly in areas having insufficient surface water resources.

Advantages of Ground Water: Ground water offers many advantages as compared to surface water reservoirs. Ground water reservoirs do not suffer seepage losses and losses due to evapotranspiration. Ground water sources are relatively simple to develop quickly near the place of use. The water from ground sources is colourless, clean and pollution free. Its quality is generally uniform which makes it as the major source of agricultural and domestic use in many areas of the world. Groundwater works as a remedy for water logging, especially where water table is high. Groundwater is harder than the surface water of the region in which it occurs. It is less likely to be contaminated.

Effects of Excessive Ground Water Uses: Excessive extraction of ground water, especially in arid and semi-arid regions, causes a sharp decline in the level of water table. Excessive irrigation with brackish water gradually raises water table and causes water logging and salinity problems. When the ground water withdrawl rate exceeds its recharge rate, the sediments in the aquifer get compacted, a phenomenon known as "ground subsidence". It may cause huge economic losses because it results in the sinking of overlying land surface associated with structural damage to buildings and sewage and pipelines. It may also increase tidal flooding. Excessive pumping of ground water results porous formations and makes the shallow well to become dry. Over use of ground water and fresh water reservoirs along coast lines often allows salt water to intrude into aquifers that are used for agricultural and domestic purposes. There are many aquifers with low recharge rates which once emptied require thousands of years to refill them. The "fossil water", when pumped out from such aquifers can not be refilled in our lifetime.

Available Water for Human Use: The Fresh Water

Available water for human use, the fresh water, is only 0.3 per cent of the total volume of water in the hydrosphere. Man has to share this usable water with the plant and animal world. According to World Water Vision, the "blue water" or renewable portion of rainfall that enters into streams and recharges ground water is the traditional focus of water management whereas "green water" or soil water is the portion of rainfall that is stored in the soil and then evaporates or is incorporated in plants and organisms. It is estimated that the total amount of available fresh water on the earth is only about 84.4 million cubic km. Much of the water on earth's surface and ground water represents deposits, which have accumulated over a long span. About 60,000,000 cubic km of fresh water is found as deposits under the land surface, about 24,000,000 cubic km locked as ice in snow caps over mountains, ice-sheets and glaciers and about 35,000 cubic km is present as soil moistures on which plants and subsoil organisms survive. Nearly 1,200 cubic km of fresh water occurs in our rivers and streams (fig 4.2).

These deposits are interrelated and interconnected. Ice sheets and glaciers regularly feed rivers, streams and underground deposits at lower altitudes when ice melts and water trickles down. Water lying in high altitude lakes and underground strata also seeps down and trickles out under the influence of force of gravity and further adds to rivers and streams. The rivers and the streams flow over long distances catering to the need of people living all along their course. Also they transport large quantity of sediments rich in plant nutrients which are deposited in low

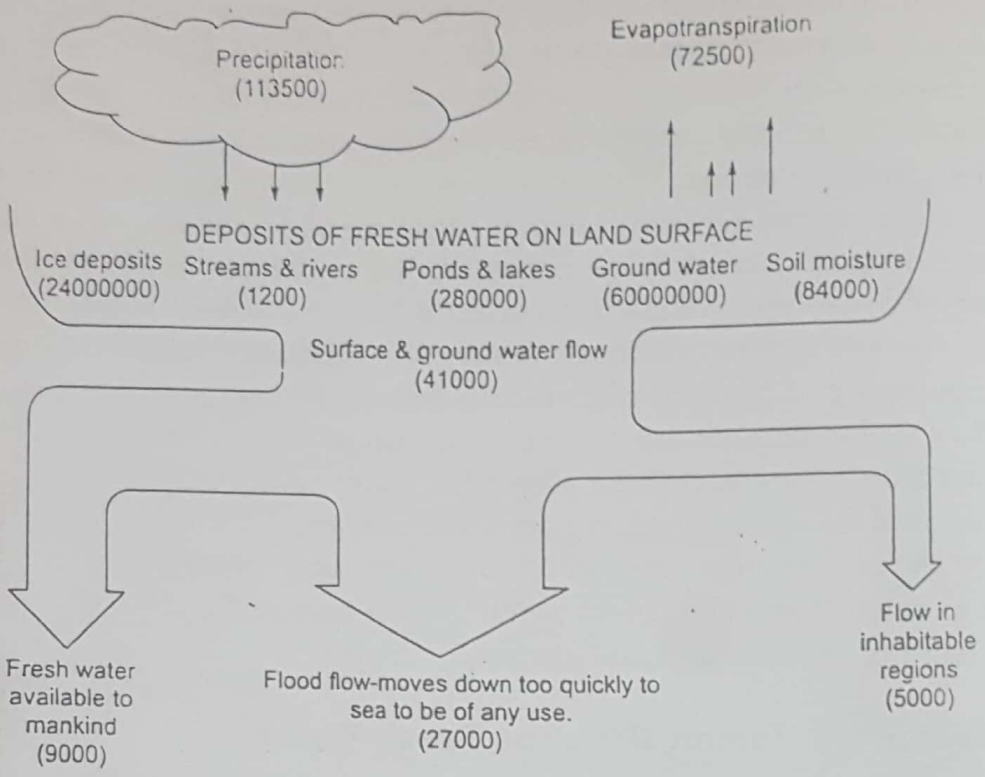

Fig. 4.2. Fresh water system (values in cubic kms.)

lying areas in a broad zone all along their course. Water seeping down the beds of rivers replenishes and recharges ground water table on either side to a reasonable distance even in dry months making ground water available at convenient depths. It is these deposits which fulfil most of human needs of fresh water. Based on data available, it is estimated that in the year 2000, about 9605 cubic km of water was drawn for human use from these deposits. And this quantity shall be about 14,102 cubic km by the year 2025.

Global fresh water resources have their own limitations. Their withdrawl beyond the limits shall diminish this natural resource base and bring about the adverse changes in the environment: the greenery shall disappear, flora and fauna shall undergo changes and desertifications will succeed. Data regarding global availability of fresh water indicate that South America, South Asia and North America occupy first, second and third ranks, respectively. Among regions of the world facing scarcity of fresh water are Kuwait, Quatar, Malta and Lybia. Among global withdrawal of fresh water, Middle East is at the top. Future estimates of water consumption depict a grim picture. By 2000 we have drawn more water than the total amount of renewable water available to us. By 2025 fresh water supply and demand situation would appear pretty grim and will compel us towards water economy, to take steps to recharge and replenish the ground water deposits and to raise our surface storage or rainwater harvesting capacity.

the concept of eco-relation of nature. Many of us may not be there to see the completion of the project. This is quite likely that future generations may have to pay in their future.

USE AND OVERUTILISATION OF SURFACE AND GROUND WATER

The total global water use has steadily increased throughout recorded history. People throughout the world are least hesitant about use and misuse of water. A clear and detailed analysis of the total global water use in recent decades indicated that the rate increase accelerated markedly after 1940 in the twentieth century as compared to earlier periods (fig. 4.3). The trends observed in the twentieth century are alaming. Currently there are no visible indications that this rate will decrease in the near future. Since fresh water is a limited resource, such high rate can not be sustained for a long period in the future. There will be a stage, more likely within next 10 to 40 years, when the global fresh water use may likely level off as a result of physical, environmental, economic and political constraints, firstly in certain individual country and then globally. Nearly 5000 cubic kms annual total global fresh water use is extraordinarily high as compared to past consumption. There is no limit of total demand of usable water, which is increasing rapidly.

It also indicates that total global fresh water use has increased about 10 times from 1900 to 1999. The situation is even worse for major water consuming developing countries such as countries of South East Asia. According to World Water Vision, France, "In South and East Asia, irrigated area under the business as usual scenario grows only slightly between 1995 to 2025, while irrigation efficiency improves. The effect is in decrease in water used for irrigation from 1,359 to 1,266 cubic km a year. At the same time economic growth leads to more material possessions and greater water use by households, increasing water withdrawals for domestic use from 144 to 471 cubic km a year. This economic growth also requires larger quantities of water increasing from 153 to 263 cubic km for Asian industry. The sum of these trends is an overall increase in water withdrawls between 1995 to 2025. Thus the pressure on water resources will become even greater than was experienced in 1995, when about 6.5 million square kilometers of river basin were under high water stress. As the area increases to 7.9 million square kilometres in 2025, the number of people living in these areas also grow tremendously from 1.1 billion to 2.4 billion."

Despite the differences in estimated values of global fresh water consumption by various agencies, the net outcome of all these calculations, indicates that we are moving ahead towards an era of serious water crisis.