



GLOBAL CIRCULATION OF WATER

More than three-fourths of the earth's surface is covered by water. Water is an odorless, tasteless, substance that can naturally exist as gas, liquid and solid within a relatively narrow range of air, temperature and pressure found on the earth's surface. It is absolutely essential for survival of all living beings. Though water is apparently available in abundant quantity, there is scarcity of usable quantity of water in a large part of the world.

In this lesson we shall examine the ways by which water flows through the environment. You will learn about the global distribution of water, its different sources and how it circulates through the global hydrological (water) cycle. Though earth is not the only planet which has water, it is the only planet that has the conditions suitable for the constant global circulation of water. We shall also look into the significance of fresh water in the life processes.



OBJECTIVES

After completing this lesson, you will be able to:

- *define what is meant by fresh water;*
- *explain the importance of fresh water in nature;*
- *recall that water is a renewable resource;*
- *identify different sources of water and its importance for life;*
- *explain the term precipitation and evaporation;*
- *illustrate diagrammatically various steps involved in hydrological cycle.*

27.1 GLOBAL DISTRIBUTION OF WATER

A little over 97% of the water on earth is salt water which is present in the oceans. We cannot drink salt water or use it for irrigation of crops. It is technologically possible to



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remove salt from ocean water, but then it is a very expensive process. Only 2.7% of the water present on earth is fresh water and it contains less than 1000 ppm of dissolved solid of any type. About 2% of the earth's fresh water (i.e. about 66% of all fresh water) is in solid form, locked in ice caps of Antarctica and glaciers that occupy high alpine locations. Because it is frozen and far away, fresh water in ice caps is not available for use. That leaves about 1% of all the earth's water in a form useable to humans, plants and land animals. The fresh water is found in lakes, rivers, streams, ponds and in the ground. A small amount (0.001%) of water is found as vapor in the atmosphere (Fig. 27.1). The distribution of fresh water, however, is geographically uneven, varying greatly from country to country and even within a country from one region to another region.

For instance some areas of the world have a rich supply of fresh water, while others are arid or semi arid areas with limited supplies. In certain areas, much of the rain water is not used due to lack of adequate arrangements for storing water. Thus, much of this water is wasted, or cause serious flooding, with resultant loss of life and property.

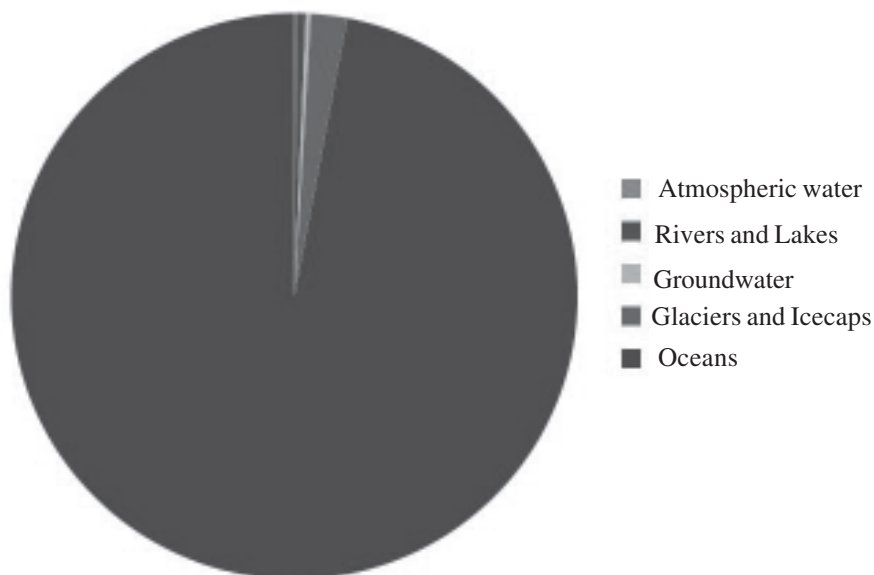


Fig. 27.1: Distribution of water on earth.

Though water is a renewable resource, but fresh water is finite. Fresh water is a scarce resource in many parts of the world including India. It is under increasing pressure as a result of pollution of water sources and increasing demand of the growing population. Worldwide consumption of water has increased six fold. This is more than twice the rate of population growth.

**INTEXT QUESTIONS 27.1**

1. Which part of earth is covered with water?

2. To be considered as fresh water, how much solids can be there?

3. In arid and semi arid areas what is true regarding the amount of water present.



Notes**27.2 IMPORTANCE OF WATER FOR LIFE AND HABITAT**

- Water is an inescapable necessity for all life on earth. It is the most important component of protoplasm in the cells of living organisms. On an average, 70% of our body is made up of water. Water is also the only source of hydrogen and one of the many sources of oxygen available to the body through metabolic processes.
- Water is also an important ecological factor that determines the structure and functioning of ecosystem. The different biomes of the earth are the result of the differences in temperature and precipitation patterns in those regions. In fact, the cycling of all other elements depends on water as it serves as a medium for their transportation during the various steps and is the solvent medium for the nutrient uptake by the plants and other organisms.
- The world's oceans have an even greater effect on global warming than forests do. Water has a greater capacity for heat absorption, and since the greater part of the earth's surface is covered by water, the temperature of the atmosphere remains fairly constant. In addition to the climate moderating influence of oceans, they also support an enormously large population of photosynthetic plankton that account for most of the photosynthesis on the earth. As you would recall, without photosynthesis there would not be enough oxygen to support life.
- Fresh water ecosystems are the main sources for drinking water, agriculture, industry, sanitation, as well as for fresh water fisheries. Fresh water also provide recreational opportunities (swimming, rafting, snorkeling) and a means of transportation (ships, boats, canoe etc). In addition, fresh water ecosystems are home to numerous organisms (fish, amphibians, aquatic plants and invertebrates). It has been estimated that 40% of all known fish species on earth are found in fresh water ecosystems.
- Human survival since the ages has depended on the relationship between human settlements and availability of fresh water resources. Many early civilizations have

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grown and flourished on riverbanks. Availability of fresh water at appropriate times and in suitable quantity and quality is vital to ecological health of a country as well as vital to the towns and cities. It is required for irrigation, domestic use and industrial needs. Worldwide approximately 70% of water is used for agriculture and only 1.1% is used for domestic and municipal supplies and the rest is used by various industries.

No matter whom we are or where we are, we all depend on water in so many ways. We need it to stay healthy, for its sheer life giving properties. However, despite the importance of fresh water resources in our lives, we are beginning to take this resource for granted. Much water is being wasted, used inefficiently and polluted through human activities. Per capita availability of fresh water is declining all over the world. In the past two decades, as a result of developments and mismanagement of fresh water resources have resulted in huge water shortages. Water crisis has not only affected crop production but it has also impacted the environment quality, wildlife and other living creatures.

Fresh water resources form an intrinsic part of the earth's hydrological cycle. You will learn more about the global hydrological cycle in the next section.

**INTEXT QUESTION 27.2**

1. State any two important uses of water for maintaining life on earth.

2. Why did early civilizations settle near river banks?

3. Why there is an increasing shortage of fresh water? Give two reason?

27.3 GLOBAL HYDROLOGICAL CYCLE

Fresh water for human needs and the maintenance of the natural environment and ecosystems is supplied through a continuous movement of water in all its forms (ice, liquid and vapour), by a system known as **hydrological cycle**. This cycle is driven by solar energy. It involves a continuous recycling of water between the atmosphere, land and oceans by several processes (Fig. 27.2). Within the atmosphere vertical and horizontal air movements including winds, transfer moisture from place to place. The streams, rivers, glaciers transfer water from land to the oceans where large scale currents transfer water within the oceans.



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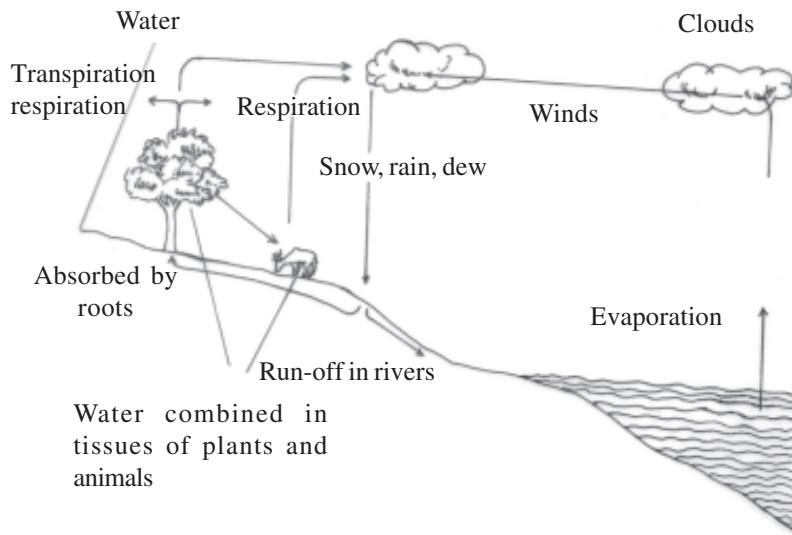


Fig. 27.2: Global hydrological cycle

The three main processes involved in the hydrological cycles are –

- evaporation and evapotranspiration;
- precipitation and
- surface runoff.

Atmospheric water, surface water and ground water are all part of this hydrological cycle. Let us now consider how water recycles within and between these regions through the above mentioned processes.

27.3.1 Evaporation and evapotranspiration

The largest reservoirs of water on the earth's surface are the oceans. Studies have shown that the oceans, seas and other water bodies like lakes, rivers and streams provide about 90% moisture to the atmosphere through evaporation each day. You are familiar with the term **evaporation**. It is the phase change of liquid water into vapour or gas on heating. This heat as you know is provided by the sun. In addition, some portion of water vapour enters the atmosphere through sublimation, a process by which water changes from solid state that is ice, directly into vapour without changing into liquid form. Also, plants lose large quantities of water through **transpiration** release about 10% of the water in the atmosphere. During transpiration water is transferred through the soil by capillary action and from the soil through the roots of the plants by osmosis and then taken up to the leaves. Since it is difficult to separate the processes of transpiration and evaporation, **evapotranspiration** is generally used for describing the combined process of evaporation and transpiration. These three processes together provide all the water to the atmosphere.

**Notes****27.3.2 Precipitation**

After water enters the lower atmosphere, it is carried upwards by the rising air currents. High up in the atmosphere the air cools and loses its capacity to hold water vapour. As a result the excess water condenses i.e., changes from vapour to liquid and forms cloud droplets. The droplets ultimately grow in size and cause **precipitation**. These are four major types of precipitation namely drizzle, rain, snow and hail. Thus most of the water is returned to the oceans and on land in the form of rain, snow, hail etc.

27.3.3 Surface runoff

When precipitation falls over land, it travels through various routes. Some of it evaporates back into the atmosphere; some of it enters the ground and is stored as ground water. Ground water is found in two layers of the soil:-

- Zone of aeration where the gaps are completely filled with water.
- Zone of saturation where the gaps are filled with water air as well as water. Boundary between these two zones is known as the **water table**, which rises or falls as the level of ground water increases or decreases.

This water is discharged either directly or indirectly into the rivers and seas by way of springs. The rest of the water moves as surface runoff into streams and rivers and ultimately flows into the ocean or other water bodies from where it enters the cycle again.

At different stages of the water cycle human beings and other organisms intercept it and withdraw water for their use. As water continually evaporates, condenses and precipitates, the rate of evaporation and rate of precipitation at a global level is equal and the total amount of water vapour in the atmosphere is approximately the same over time. But evaporation over the continents is less than precipitation while the converse is true over the oceans.

27.3.4 Balance and stores of water

The total volume of water in the hydrological cycle is estimated approximately to be 1,384 million km². The global water cycle involves many complex pathways and stores. At any time, maximum water is stored in the oceans and seas (Table 27.1). Most of the freshwater as mentioned earlier is stored as ice and in polar caps and in glaciers. If all of this ice were to melt then it would release enough water to keep the rivers of the world flowing for up to 1000 years!



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Table 27.1: Natural stores of water in the global hydrological cycle

Stores	Percentage (%)
Oceans	97.71
Ice caps	1.9
Ground water	0.5
Soil moisture	0.01
Lakes and rivers	0.009
Atmosphere	0.0001

Though rivers play a vital role in the water cycle, they are not the major stores of water in the way that oceans are. They are conduits rather than stores. Lakes stores more water than rivers and for a longer time. About two thirds of all fresh water on the surface is stored in the 250 large lakes of the world.

Water moves through these stores and this movement keeps the hydrological cycle running, though different stores keep the water for different times. Oceans, ice caps and glaciers are long term stores, whereas rivers and atmosphere are short term stores. It becomes clear from table 27.2 and fig.27.1 that relatively small amounts of water are recycled very fast and most of the water is trapped in long term stores.

Table 27.2: The global water cycle storage times

Store	Typical residence time
Plants and animals	1 week
Atmosphere	8-10 days
Rivers	2 weeks
Soil	2 weeks to a year
Lakes, reservoirs, wetlands	Years
Ground water	Days to thousands of years
Ice	Thousands of years
Oceans	Thousands of years

**INTEXT QUESTIONS 27.3**

1. What is surface run-off?

2. Name three long-term stores of water.

3. How long can water be stored in the body of a living organism?

**Notes****27.4 INDUCED CHANGES IN THE HYDROLOGICAL CYCLE**

Human activities can alter the global water cycle in many ways, either deliberately or by accidentally.

- The movement of water vapour across oceans and continents can be altered by air pollution which can cause global warming. Significantly changes in precipitation patterns inevitable as precipitation is dependent on ambient temperature.
- Evaporation rate and pattern change due to altered ground surface conditions. For examples, urbanization or development of reservoirs affect evaporation rate.
- Increasing or decreasing the length or density of the river channels, can directly change river runoff.
- Ground water can be affected by pumping out excessive water that lowers the water table or through increased percolation of due to water logging to development of reservoirs and dams.
- Altering the vegetation pattern from deforestation, cropping or afforestation etc. can significantly greater influence of runoff water.

**INTEXT QUESTIONS 27.4**

1. How does global warming change movement of water vapour across oceans and continents?

2. How can river run-off be altered?

3. State one way of reducing water table.

**WHAT YOU HAVE LEARNT**

- Water is probably the most important renewable natural resource on planet earth.
- 97.41% of the water on earth is salt water found in the oceans. About 2% of the earth's fresh water is in solid form, locked in ice caps and glaciers. This fresh water is found in lakes, rivers, streams, ponds, and in the ground.
- Water is essential for life, and since the earliest time humans have relied on fresh water ecosystems for drinking water, for agriculture, industry, sanitation, as well as for food.



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- Much water is being used inefficiently and polluted through human activities and per capita availability of fresh water is declining all over the world.
- Fresh water resources form an intrinsic part of the earth's hydrological cycle.
- The hydrological cycle involves the continuous recycling of water between the atmosphere, land and oceans.
- The basic structure of the cycle is simple. Water is evaporated from oceans, rivers, lakes and vegetation, becomes part of the atmospheric moisture. Global winds distribute this across the earth's surface. Condensation creates clouds and precipitation brings it back to the surface from where it evaporates to re-enter the global water cycle.
- Human activities can alter the global hydrological cycle in several ways.



TERMINAL EXERCISES

1. How does hydrological cycle is driven?
2. In which form water locks in ice caps?
3. Where did primitive human settlement find?
4. 'Living beings cannot survive without water'. Explain this statement in your words.
5. Draw a neat diagram to depict the movement of water in the hydrological cycle.
6. What is the role of oceans in the water cycle?
7. What is precipitation? When does it occur?
8. State three ways by which usable water is becoming scarce.
9. What is meant by global circulation of water?
10. Explain in brief about the various steps involves in hydrological cycle.



ANSWERS TO INTEXT QUESTIONS

27.1

1. More than $\frac{3}{4}$
2. Less than 1000 ppm
3. limited

Water Resource
Management**Notes****27.2**

1. Metabolic source of hydrogen (H)/ component of protoplasm/ resource for agriculture/ keeps atmospheric temperature within limits or constant
2. Water was available easily for consumption/irrigation.
3. Water is wasted/used inefficiently/ polluted (any two)

27.3

1. Precipitation reaching land and traveling through various routes
2. Oceans, Ice caps, glaciers
3. 7 days

27.4

1. Changing precipitation patterns
2. Increasing or decreasing length/ density of river channels
3. Dumping out excessive water.