AN OVERVIEW OF THE MAJOR PROCESSES OF THE HYDROLOGIC CYCLE

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ABSTRACT

This work discusses the continuous movement of water on, above and below the surface of the earth. Brought into focus are the processes of the hydrologic cycle. This study is a useful starting point on the study of hydrology. The cycle begins with the evaporation of water from the ocean due to the heating of the water by the sun's radiation, thereby making it to change to water vapour and driven by air current in the atmosphere to form clouds which later condenses as rain. Processes of hydrological cycle takes place simultaneously at different rates and time. A concise history of the hydrologic cycle was also captured. Evaporation is seen as the major player in the hydrologic cycle.

Keywords: Evaporation, Hydrologic cycle, Hydrology, Water vapour.

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1.0. Introduction

Water is used for our day to day activities. It is available to us on earth in different forms/states: solid (ice), liquid (water) and gaseous (water vapour) states. Ordinarily, it is difficult to understand why water is still available in great quantities on earth in surface water bodies (rivers, stream, lakes, oceans) and underground water reserves despite the fact that we use plenty water daily. This is explained by the processes or components of the hydrologic cycle.

Hydrologic cycle can be defined as the science of the study of the occurrence and movement of water in different forms on earth. Hydrologic cycle is an act of God.

This is explained in the book of Ecclesiastes (1:7) "Every river flows into the sea, but the sea is not yet full. The water returns to where the rivers began, and starts all over again". This biblical verse is what we aim at explaining how it occurs using science.

Hydrologic cycle is the circulation of water from the sea, through the atmosphere, to the land, and thence, often with many delays, back to the sea or ocean though various stages and processes as precipitation, interception, runoff, infiltration, percolation, groundwater storage, evaporation and transpiration, also the many short circuits of the water that is reformed to the atmosphere without reaching the sea[1].

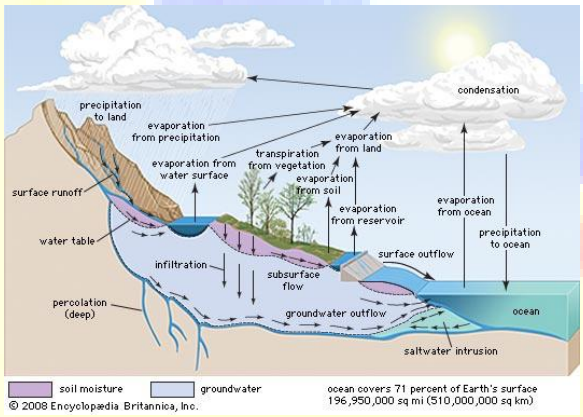

Fig 1. Water cycle processes

Source: [2]

1.1. The Concept of the Hydrologic Cycle

The concept of the hydrologic cycle is a useful starting point on the study of hydrology. The cycle (fig 1) is visualized as beginning with the evaporation of water from the oceans. The resulting vapour is transported by moving air masses. Under the proper conditions, the vapour is condensed to form clouds, which in turn may result in precipitation. The precipitation which falls

upon land is dispersed in several ways. The greater part is temporarily retained in the soil near where it falls and is ultimately returned to the atmosphere by evaporation and transpiration by plants[3].

A portion of the water finds its way over and through the surface soil to stream channels, while other water penetrates farther into the ground to become part of the ground water. Under the influence of gravity, both surface stream flow and groundwater move toward lower elevations and may eventually discharge into the ocean. However, the substantial quantities of surface and underground water are returned to the atmosphere by evaporation and transpiration before reaching the oceans.

Above description of the hydrologic cycle and the schematic diagram of fig 1 are enormously over-simplified. For instance, water from some surface streams may percolate to the groundwater, while in other cases groundwater is a source of stream flow. Some precipitation may remain on the ground as snow for months before melting releases the water to streams or groundwater. The hydrologic cycle is a convenient means for delineating the scope of hydrology as the portion between precipitation on the land and the return of this water to the atmosphere or ocean. The movement of water through the cycle is not a continuous mechanism through which water moves steadily at a constant rate; but erratic, both in time and over area.

Water on earth exists in a space called the hydrosphere which extends about 15km up into the atmosphere and about 1km down into the lithosphere, the crust of the earth. Water circulates in the hydrosphere through the maze of paths constituting the hydrologic cycle. The hydrologic cycle is the central focus of hydrology[4]. The cycle has no beginning or end, and its many processes occur continuously.

The water cycle, also known as the hydrologic cycle describes the continuous movement of water on, above and below the surface of the earth. The mass of water on earth is fairly constant over time but the division of the water into the major reservoirs of ice, fresh water, saline water and atmospheric water is variable depending on a wide range of climatic variables. The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff and sub surface flow. In doing so, the water goes through different phases: liquid(water), solid (ice), and gas (vapour). The evaporative phase of the cycle purifies water which then replenishes the land with fresh water[5]. The flow of liquid water and ice transports minerals across the globe. It is also involved in reshaping the geological features of the earth, through processes including erosion and sedimentation. Most life and ecosystem on the planet are maintained by the water cycle. The sun drives the water cycle by heating water in oceans and seas, thereby making it to evaporate as water vapour into the air.

2.0. Processes of Hydraulic Cycle

Hydrologic processes transform the space and time distribution of water throughout the hydrologic cycle[4]. The motion of water in a hydrologic system is influenced by the physical properties of the system, such as size and shape of its flow paths, and by the interaction of the water with other working media, including air and heat energy.

2.1. Precipitation

This is condensed water vapour that falls on the earth's surface. Only about one fourth the total precipitation that falls on continental areas is returned to the seas by direct runoff and underground flow. Forms of precipitation include drizzle (or moist), glaze, rime, snow, hail, sleet. Most precipitation occurs as rain, but also includes snow, hail, fog drip, graupel, and sleet[6]. Approximately 505,000 km^3 (121,000 cu mi) of water falls as precipitation each year, 398,000 km^3 (95,000 cu mi) of it over the oceans [7]. The rain on land contains 107,000 km^3 (26,000 cu mi) of water per year and a snowing only 1,000 km^3 (240 cu mi) [8]. 78% of global precipitation occurs over the ocean[9]. Air currents move water vapour around the globe, cloud particles collide, grow, and fall out of the upper atmosphere layers as precipitation.

2.2. Evaporation

The water on different water bodies, on land is heated up as a result of radiation from the sun and it changes to water vapour (gas) which is transported by air current in the atmosphere by moving it upwards to form clouds (drops of water vapour). This involves the transformation of water from liquid to gas phase as it moves from the ground or bodies of water into the overlaying atmosphere [7]. The source of energy for evaporation is primarily solar radiation.

2.3. Transpiration

The movement of water from the leaves of plants and vegetation where it changes into water vapour and carried by air current to upper atmosphere to form clouds.

Evaporation and transpiration are together called evapotranspiration. The total annual evapotranspiration amounts to approximately 505,000 km^3 (121,000 cu mi) of water, 434,000 km^3 (104,000 cu mi) of which evaporates from the oceans [7]. 86% of global evaporation occurs over the ocean [9].

2.4. Runoff

The water that moves on the ground surface after rainfall. It is also called overland flow. It is the variety of ways by which water moves across the land. This includes both surface runoff and channel runoff. As it flows, the water may seep into the ground, evaporate into the air, become stored in lakes or reservoirs, or be extracted for agricultural or other human uses.

2.5. Infiltration

The flow of water from the ground surface into the ground. Once infiltrated, the water becomes soil moisture or groundwater[11].

2.6. Subsurface Flow

The flow of water underground, in the vadose zone and aquifers. Subsurface water may return to the surface (eg. as a spring or by being pumped) or eventually seep into the oceans. Water returns to the land surface at lower elevation than where it infiltrated, under the force of gravity or gravity induced pressures. Groundwater moves slowly, and is replenished slowly, making it possible for it to remain in aquifers for thousands of years.

2.7. Sublimation

The state change, directly of solid water (snow or ice) to water vapour[12]. Snow and ice may be heated (absorb energy) from the sun (solar radiation) and change directly to water vapour (gas).

2.8. Percolation

Movement (flow) of water vertically through the soli and rocks under the influence of gravity.

3.0. History

In ancient times, it was thought that the land mass floated on body of water, and that most of the water in rivers has its origin under the earth.

By roughly 500 BCE, Greek scholars were speculating that much of the water in rivers can be attributed to rain. The origin of rain was also known by them. These scholars maintained the belief, however, that water rising up through the earth contributed a great deal to rivers. Examples of this thinking included Anaximander (570 BCE), who also speculated about the evolution of land animals from fish[13] and Xenophanes of Colophon (530 BCE)[14].

Chinese scholars such as Chi Ni Tzu (320 BC) and Lu Shih Ch'un Ch'iu (239 BCE) had similar thoughts. The idea that the water cycle is a closed cycle can be found in the works of Anaxagoras of Clazomenae (460 BCE) and Diogenes of Apollonia (460 BCE). Both Plato (390 BCE) and Aristotle (350 BCE) speculated about percolation as part of the water cycle.

Up to the time of the Renaissance, it was thought that precipitation alone was insufficient to feed rivers, for a complete water cycle, and that underground water pushing upwards from the oceans were the main contributors to river water. Bartholomew of England held this view (1240 CE), as did Leonardo da Vinci (1500 CE) and Athanasius Kircher (1644 CE).

The first published thinker to assert that rainfall alone was sufficient for the maintenance of rivers was Bernard Palissy (1580 CE), who is often credited as the "discoverer" of the modern theory of the water cycle. Palissy's theories were not tested scientifically until 1674, in a study commonly attributed to Pierre Perrault. Even so, these beliefs were not accepted in mainstream science until early nineteenth century[15].

4.0. Discussions and Conclusion

The phenomenon of hydrologic cycle is not a new discovery in science. We have seen that it was discovered in ancient time by many scholars. It is a natural phenomenon through which water is always available in abundance on earth. The quantity of water on earth is fairly constant over time. What changes is its division into the major reservoirs of ice, fresh water, saline water and atmospheric water. This is variable depending on climatic conditions. In this work, it was seen that evaporation which is the principal component of the hydrologic cycle is also a natural water purification means.

In conclusion, nature is so friendly with us that it provides us with water in abundance at different locations and forms on earth. It should be ensured that it is preserved to enable its usage for its numerous purposes.

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