NATURAL WATERS

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Contents

Summary

Water is necessary for humans, animals and plants to survive. It is also needed for industrial activity and food production. The water on the Earth, about 1.38 billion cubic kilometers, is distributed in the air, in the oceans, on the land as lakes, rivers, groundwater, in soil and in biological systems. Seawater covers 360 million square kilometers of the Earth, approximately 71% of the surface. Seawater contains almost every known naturally occurring element. Just six elements, chlorine, sodium, sulfur, magnesium, calcium, and potassium, comprise about 99% of sea salts. Seawater contains 34 to 36% salinity mainly chloride ions. Rain is the most useful source of water

for drinking, industrial use and agriculture use. Average precipitation in the world is about 1,000 mm annually. Rainwater is basically pure, however, it picks up various trace elements in the atmosphere as it falls to the ground. Terrestrial water is called inland water, and mainly consists of rivers, lakes, ground springs, snow and ice. Surface water generally contains Na, K, Mg and Ca as cations, and Cl, SO_4, HCO_3 as anions. Groundwater totals about 0.23 billion cubic kilometers. Water dissolves minerals from the rocks with which it comes in contact. The most common dissolved mineral substances are the same as in surface water. Glaciers and ice are found in low temperature regions such as high mountain areas or cold districts. In general, the elements are almost the same as the elements in rain.

1. Introduction

The Earth is dominated by water. Estimates vary, but somewhere about 71 percent of the Earth's surface is covered with water. The hydrosphere contains about 1.38 billion cubic kilometers in the air as water vapor and on the surface as groundwater mostly in the form of a liquid. Water is also essential for life, being the major constituent of almost all living bodies. Most animals and plants contain more than 60 percent water by volume. Clean water is necessary for industrial activity and human life. However, water is often contaminated with aquatic microorganisms, and inorganic and organic materials with artificial activity. This chapter describes water quality or the characteristics of natural water.

2. Characteristics of Water

Water has a simple atomic structure, two hydrogen atoms bound to one oxygen atom. It has several unique physical properties

- Water in a pure state has a neutral pH. The pH of pure water changes when some substances are dissolved in water. The pH of rainwater is usually about 5.6 for naturally dissolved carbon dioxide and sulfur dioxide.
- Water exists as a liquid form over a range of temperatures from 0-100 ^{o}C. This range allows water to remain as a liquid in most places on the Earth.
- Liquid water is able to dissolve a large number of chemical compounds. This feature also enables water to carry solvent nutrients in runoff, infiltration, groundwater flow and living organisms.
- Water conducts heat more easily than any liquid. This fact causes large bodies of water like lakes and oceans to have essentially a uniform vertical temperature profile.
- Water exists in all three physical states; solid, liquid, and gas. Incorporated in the changes of state are massive amounts of heat exchange.
- The freezing of water causes it to expand. When water freezes it expands rapidly adding about 9% by volume. Fresh water has a maximum density at around 4^{o}C.

The density of water at various temperatures is shown in Table 1.

Temperature (^{o}C)	Density(g/cm^{3})
0 (solid)	0.9150

0 (liquid)	0.9999
4	1.0000
20	0.9982
40	0.9922
60	0.9832
80	0.9718
100(gas)	0.0006

Table 1: Density of water at various temperatures

3. Distribution of Water on the Earth

The water on the Earth, about 1.38 billion cubic kilometers in volume, is distributed in air, ocean, and surface water including lake, river, ground, soil and biological system.

3.1. Distribution

One estimate of the global distribution of water is shown in Table 2. According to this estimate, about 1.386 billion cubic kilometers of water exists on the Earth. Almost all this water is distributed as seawater, about 96.5% of total volume. Approximately 1.7% is stored in the polar icecaps, glaciers and permanent snow, and another 1.7% is stored in groundwater, lakes, rivers, streams and soil. Groundwater, with a volume of 0.23 billion cubic kilometers, contains 0.1 billion cubic kilometers of fresh water and 0.13 billion cubic kilometers of saline water. Lake water (176.4×10^3 Km^3) contains 91.0×10^3 Km^3 of fresh water and 85.4×10^3 Km^3 of saline water. The atmosphere contains about 12.9×10^3 Km^3 of water mostly in the form of water vapor

	Volume($1000km^3$)	**Total water(%)**	**Fresh water(%)**
Seawater	1,338,000	96.5	-
Ice caps, glaciers and snow	24,064	1.74	68.7
Groundwater	23,400	1.7	30.1
Soil moisture	16.5	0.001	0.05
Ground ice, permafrost	300	0.022	0.86
Lakes	176.4	0.013	0.26
Swamp water	11.47	0.0008	0.03
Rivers	2.12	0.0002	0.006
Atmosphere	12.9	0.001	0.04
Biological water	1.12	0.0001	0.003
Total	1,385,984	100	100

Table 2: Estimated global water distribution

3.2. Water Cycle

Water is always cycling around, through, and above the Earth, continually changing from a liquid to vapor to ice. The hydrologic cycle describes the row water as water molecules make their way from the Earth's surface to the atmosphere, and back again. This gigantic system, powered by energy from the sun, is a continuous exchange of moisture between the oceans, the atmosphere, and the land. The oceans, and other water bodies such as lakes, rivers and streams, provide nearly 90% of the moisture in the atmosphere. Liquid water leaves these sources as a result of evaporation, the process by which water changes from a liquid to a gas. In addition, a very small portion of water vapor enters the atmosphere through a solid (ice or snow) to a gas. Plants through transpiration release another 10% of the moisture found in the atmosphere. The moisture reaches the high atmosphere, where the air cools and loses its capacity to support water vapor. Moisture changes from a gas to form cloud droplets, which can eventually grow and produce precipitation such as rain, snow, and freezing rain. This is the primary mechanism transporting water from the atmosphere back to the Earth's surface. About 91% of evaporated water is returned to the ocean basins by way of precipitation. The remaining 9% is transported to areas over landmasses by way of precipitation.. When precipitation falls over the landmasses, it follows various routes. Some of it evaporates, returning to the atmosphere, and some seeps into the ground as soil moisture or groundwater. The rest of the water runs off into rivers and streams, and almost all of this water eventually flows into the oceans.

Water utilizable for industrial and human use accounts for only about 0.04% of the total amount of surface water and groundwater. It is important to maintain the quality of water resources.

4. Seawater

Ocean covers 360 million square kilometers, approximately 71%, of the surface of the Earth. On average, the world's oceans are about 4000 m deep and about 1340 million cubic kilometers in volume. Seawater accounts for about 97% of all the water on Earth. Seawater is a mixture of various salts and water. Most of the water in ocean basins is believed to originate from the condensation of water found in the early atmosphere as the Earth cooled after its formation. This section describes the physical and chemical characteristics of seawater.

4.1. Constituents of Seawater

Seawater consists of weak diluted salt water which has dissolved various elements from weathering and encroachments of rock and stone. The chemical constituents of seawater originate from six sources.

- Degassing of the earth's mass (releasing of volatile chemicals) that began after the Earth's formation and continues today during volcanic activity
- Erosion of sediments and basalts on land by weathering
- Seawater reactions with basalt extruded under the sea that release chemicals into seawater
- Biological processes that produce organic chemicals and cycle bioreactive elements

- Photochemical reactions that occur in the upper pelagic waters
- Radioactive decay of elements that yield other elements

4.2. Main Elements of Seawater

Seawater contains almost every known naturally occurring element. The main chemical elements, five cations and anions, in seawater are listed in Table 3. Just six elements,

chlorine (Cl^-), sodium (Na^+), sulfur(SO_4^{2-}), magnesium(Mg^{2+}), calcium(Ca^{2+}), and potassium(K^+), comprise about 99% of sea salts. Calculations of seawater salinity are made in parts per 1000 of the chlorine ion present in one kilogram of seawater. Average salinity is 35%, but most seawater varies from 34 to 36%. Seawater near the coast which flow into river water has low salinity, and actively evaporating areas show high salinity, for example, the Red sea' s salinity is 41%. The total concentration of main components in seawater varies depending on location, however, the ratio of main components is almost the same in the open ocean. For example, the calculated ratio of K/Cl shows a constant value of 0.0205±0.0007 from the Arctic Ocean to the Black Sea.

Component	Concentration (mg kg^{-1})	Percentage of Salinity
Chloride(Cl^-)	18.98	55.03
Sodium(Na^+)	10.56	30.59
Sulfate(SO_4^{2-})	2.65	7.68
Magnesium(Mg^{2+})	1.27	3.68
Calcium(Ca^{2+})	0.40	1.18
Potassium(K^+)	0.38	1.11
Bicarbonate(HCO_3^-)	0.14	0
Bromide(Br^-)	0.07	0
Borate(H_3BO_3)	0.03	0

Table 3 Concentrations of main elements in seawater

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Biographical Sketch

Yoshiteru Tsuchiya is a Lecturer in the Faculty of Engineering of Kogakuin University, where he has been in his present post since 2000. He obtained a Bachelor Degree in Meiji Pharmaceutical College in 1964. He worked for Department of Environmental Health in Tokyo Metropolitan Research Laboratory of Public Health until 2000. In the meantime, he obtained a Ph.D in Pharmaceutical Sciences from Tokyo University. From 2002 to 2003, he worked for the Yokohama National University Cooperative Research and Development Center as Visiting Professor.

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