# HYDROLOGIC CYCLE AND WATER USAGE

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**Contents**





**Summary**

The stocks of water and the hydrologic cycle on the Earth are quantitatively described and the present statuses of water balances and usage in Japan and the USA are compared. The necessity and usefulness of wastewater reuse for saving the limited water resources in the world is also discussed.

## 1. Stocks of water on the Earth

Water is the origin of life. If there were not water on the Earth, no living things would have come into existence. The life of a living organism is maintained by water contained within its body. Water accounts for about 70% of the body-weight of adult humans, and as much as 80% of that of new-born babies. Generally, the body of a fish is about 75% water; jellyfish, however, contain as much as 96% water. An adult human needs to drink about two liters of water every day. In addition to sustaining the life of every cell, water is also used for many other purposes, such as temperature control, transportation, dissolving materials, washing, maintaining the functions of natural ecosystems, etc. Water is clearly one of the essential resources for human activities.

Water present everywhere on the Earth. It exits in the seas, lakes, ponds, rivers, and under the ground. It also exits in glaciers and mountains as ice and/or permanent snow. Water is also contained in living things, plants, soils and the atmosphere. The water located in lakes, ponds, and rivers is called surface water and that located under the ground is called groundwater or subsurface water. Fresh surface water and groundwater are major water resources for human activities. The stocks and location of water on the Earth are shown in Table 1.

| Location | Amount ($10^3$ km$^3$) | Percentage* |
|---|---|---|
| Oceans | 1,357,000 | 96.26 |
| Subsurface | 25,700 | 1.82 |
| Rivers | 1.4 | 0.00099 |
| Freshwater lakes | 91 | 0.0065 |
| Saline lakes | 85 | 0.0060 |
| Glaciers (ice and permanent snow) | 26,410 | 1.87 |
| Soil | 80 | 0.0056 |
| Atmosphere | 13 | 0.00092 |
| Living biomass | 1.2 | 0.000085 |
| **Total** | **1,409,607** | |

*The approximate values (the sum of the data does not equal to 100%)

Table 1. Stocks of water on the Earth
Data from Naganuma, 1978 and Masters, 1997

The water in the seas is estimated to be 1 357 000x$10^3$ km$^3$. This is based on the total area of the World Ocean being about 361x$10^6$ km$^2$, and the mean depth about 3800 m. More than 96% of the world's water is located in the seas. The amount of groundwater is about 25 700 x $10^3$ km$^3$, which accounts for about 1.82% of the total stock of water in the world, and half the total fresh water. The water in fresh lakes, ponds and rivers is 92 x$10^3$ km$^3$, which is only 0.007% of total water and 0.18% of fresh water. The amount of water in the forms of ice and permanent snow is about 26 410 x $10^3$ km$^3$, which is nearly equal to the amount of groundwater.

The total area of glaciers and ice sheets in the world is about 16 x $10^6$ km$^2$ (about 10% of the land area), and 90% of that is located in Antarctica. The amount of water in soils is about 80 x $10^3$ km3, which is similar to the volume stored in fresh lakes. The water contained in the atmosphere is only 13 x $10^3$ km$^3$, or 0.0009% of total water. In addition to water vapor, it includes various natural phenomena such as clouds, rain and snow.

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**Bibliography**

Fujita S. and Sono K. (1990). Water and lives (living science of water). 1-5. Tokyo: Makishoten Co., Ltd. [In Japanese]. [This book discusses the function and importance of water for living things].

Goto N, Hu H.-Y. and Fujie K. (1999). Energy consumption and material flow in Japanese sewage treatment plant, *Proceedings of 7th IAWQ Asia-Pacific Regional Conference* , Vol.1, p.59-64. [This paper overviews the material flow and amount of energy consumed in Japanese sewage treatment plants].

Master G.M. (1997). Introduction to environmental engineering and science (2nd ed.). 164-170. New

Jersey: Prentice Hall, Inc. [This book gives a brief and systematic introduction on principles of environmental engineering and science].

Naganuma N. (1978). Water sphere of the Earth. Ocean and land waters, (ed. M. Hoshino), 1-5. Tokyo: Tokai University Press. [In Japanese]. [This book gives a brief introduction to the water resources of the Earth].

National Land Agency Japan (1997). Water resources in Japan -1997. 28-51. Tokyo: Printing Bureau the Ministry of finance Japan. [In Japanese]. [This book overviews water resources in Japan].

Takeda T., Ageta Y., Yasuda N. and Fujiyoshi Y. (1994). Meteorology of water cycle. 1-4. Tokyo: University of Tokyo Press. [In Japanese]. [This book gives a systematic introduction to the water cycle on the Earth].

Tanbo N. and Ogasawara K. (1995). Water purification. 1-10. Tokyo: Gihodo Shuppann Co., Ltd. [In Japanese] [This book gives a systematic introduction to the water cycle on the Earth].

Wada H. (1992). Water recycling (Basic). 2-4. Tokyo: Chijinshokan Co., Ltd. [In Japanese]. [This book gives a systematic introduction to wastewater reclamation and reuse technologies].

WRI, UNEP, UNDP, and The World Bank (1998). World resources 1998-1999: A guide to the global environment. 302-306. Tokyo: Chuohoki Publishers. [In Japanese] [This book overviews the present condition of resources in the world].

**Biographical Sketches**

**Koichi Fujie** is a professor in the Department of Ecological Engineering at Toyohashi University of Technology, Japan. He completed his PhD in environmental chemistry and engineering at Tokyo Institute of Technology; his PhD thesis was entitled “Oxygen transfer and power economy characteristics of biological wastewater treatments”. Professor Fujie’s research and teaching interests are focused on the sustainability of human society supported by industrial activities. He stresses that minimization of resource and energy consumption, with their environment loading, are essential for sustainability. His major research fields are water and wastewater treatment, development of material recycling technology, bioremediation and design of sound material cycle networks.

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