Environment Canada
Environnement Canada

Conservation and Protection
Conservation et Protection

1

Water

Fact Sheet

Water—Nature's Magician

"Water is the solvent, the medium, the participant, and the catalyst in most of the chemical reactions occurring in our environment."

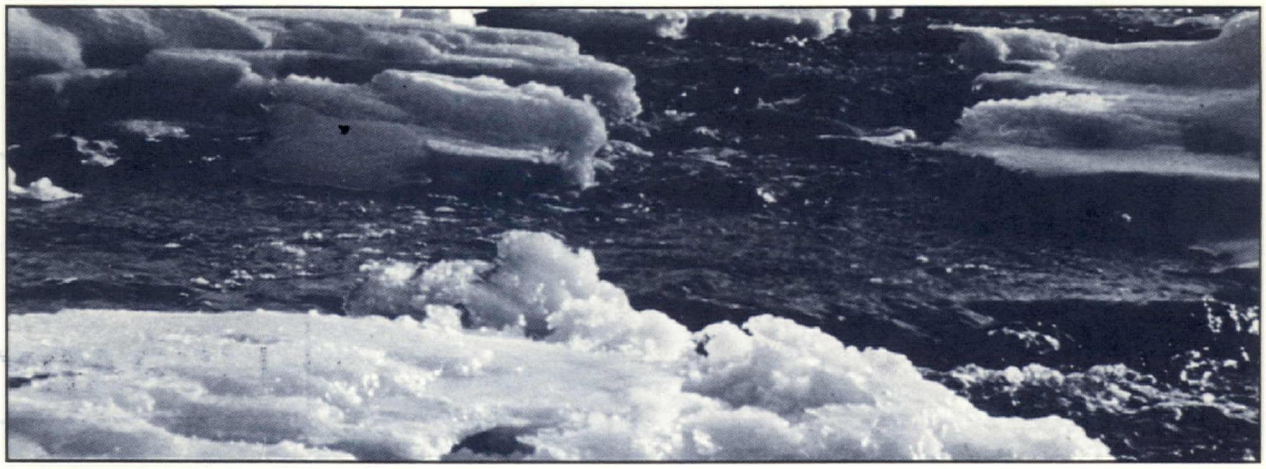
Water is at once simple and complex. A water molecule itself is simple, made up of three atoms—two hydrogen and one oxygen, H_2O. Yet water has been called "nature's magician," since it can appear in many guises, changing from one state to another —as if by sleight of hand.

Water—visible and invisible

Water is found as a liquid, as a solid (ice) or as a gas (water vapour or steam).

- Scientists estimate that as much as one seventh of the fresh, *liquid*, surface water in the world is contained within Canada's boundaries.
- The ice we skate on in winter is water in its *solid* form. Unlike most substances, which are heaviest in their solid state, ice is lighter than water and thus floats. If this were not the case, lakes and rivers would freeze from the bottom up. Fish could not survive, and it is unlikely that rivers and lakes in northern countries would ever completely thaw.
- Water *vapour* can appear as the highly visible stream of "gas" from a boiling kettle or as clouds in the sky. Water vapour forms a kind of global "blanket" which helps to keep the earth warm. Heat radiated from the sun-warmed surface is trapped and held by the vapour.

Canada



Spring breakup on the Rideau River

Water's magical properties

The hydrogen and the oxygen atoms from different water molecules are attracted toward each other, creating "hydrogen bonds." These strong bonds determine almost every physical property of water.

Boiling and freezing

Pure water at sea level boils at 100°C and freezes at 0°C. At higher elevations (lower atmospheric pressures) its boiling temperature decreases. If a substance is dissolved in water, then the freezing point is lowered. This is why we spread salt on streets in winter to prevent ice formation.

Heating and cooling

Water absorbs or releases more heat than many substances for each degree of temperature increase or decrease. This is why water is so widely used for cooling and for transferring heat in thermal and chemical processes.

A river or lake will absorb the heat of the day and cool the surrounding air as water evaporates. In the evening, when the air cools to below water temperature, the water gives off heat, often blanketing the surrounding area with mist.

Surface tension

Surface tension is a measure of the strength of the water's surface film. The strong attraction between the water molecules creates a taut sheet, which among other common liquids is only surpassed by that of mercury.

It is this surface tension that permits water to hold up substances heavier and denser than itself. This is why a steel needle carefully placed on the surface of a glass of water will float.

The rounded shape of water drops indicates the presence of surface tension, producing an effect similar to a balloon where the pressure is greater inside than outside.

Molecules in motion

Water molecules as well as binding to each other, bind to many other substances such as glass, cotton, plant tissues, and soils. This is called adhesion. For example, in a thin glass tube, when the molecules at the edge reach for and adhere to the molecules of glass just above them, they at the same time tow other molecules along with them. The water surface, in turn, pulls the entire body of water to a new level until the downward force of gravity is too great to be overcome. This process is called capillary action.

Thus water readily wets many materials. This is why a paper towel or a sponge can be used to soak up spilled water. The large potholes in our roads are also formed due to capillary action. The penetration of water combined with the extreme pressure of expansion when water freezes, splits rocks, heaves roads, and breaks up concrete walls and sidewalks. On the other hand, without this property, the nutrients needed by plants and trees would remain in the soil; and blood, which is mostly water, would not move through the smallest blood vessels, called "capillaries."

The universal solvent

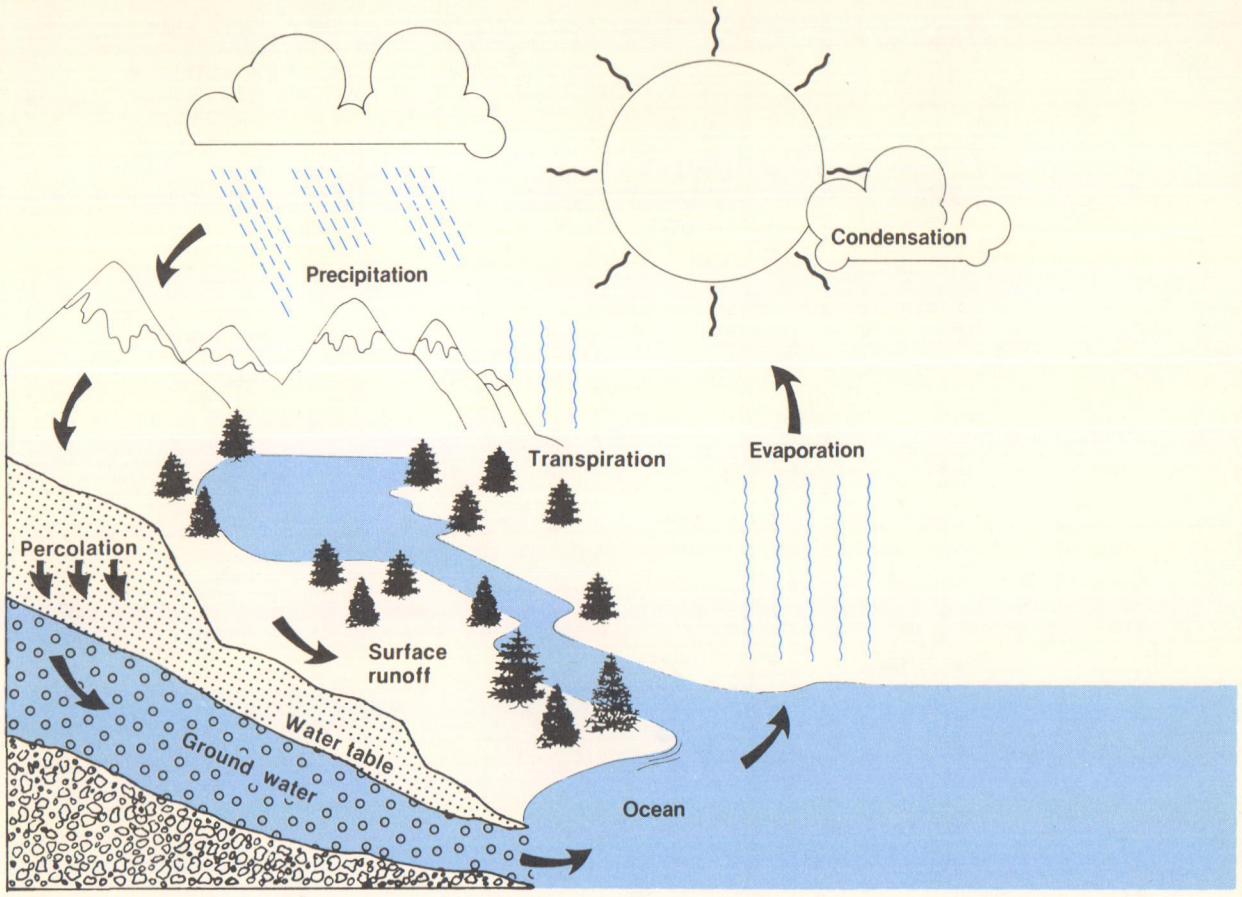
An extraordinary property of water is its ability to dissolve other substances. There is hardly a substance known which has not been identified in solution in the earth's waters. Were it not for the solvent property of water, life could not exist because in living animals and plants water transfers nutrients vital to life.

A drop of rain water falling through the air dissolves atmospheric gases. In the case of gases resulting from the combustion of sulphur- and nitrogen-containing coal and oil, acid rain is produced. When rain reaches the earth, it affects the quality of the land, lakes and rivers.

Did you know?

- Raindrops are not tear-shaped. Scientists, using high-speed cameras, have discovered that raindrops resemble the shape of a small hamburger bun.
- About 70% of the human body is water.
- Life on earth originated in water.
- More than half of the world's animal and plant species live in the water.
- Almost 75% of the earth is covered in water.
- The human body needs 2 litres of water a day in our climate; we can last only a few days without water.
- Most of our food is water: tomatoes (95%), spinach (91%), milk (90%), apples (85%), potatoes (80%), beef (61%), hot dogs (56%).

The Hydrologic Cycle



Evaporation:
As water is heated by the sun, its surface molecules become sufficiently energized to break free of the attractive force binding them together, *evaporate* and rise as invisible vapour in the atmosphere.

Transpiration:
Water vapour is also emitted from plant leaves by a process called transpiration. Every day an actively growing plant *transpires* 5 to 10 times as much water as it can hold at once.

Condensation:
As water vapour rises, it cools and eventually *condenses*, usually on tiny particles of dust in the air. When it condenses it becomes a liquid again or turns directly into a solid (ice, hail or snow). These water particles then collect and form clouds.

Precipitation:
Rain, snow and hail are all forms of precipitation that come from clouds. Clouds move around the world, propelled by air currents. When they rise over mountain ranges, they cool, becoming so saturated with water that water begins to fall as rain, snow or hail, depending on the temperature of the surrounding air.

Surface runoff:
Some of the water drains by running across the land surface into creeks, ponds, lakes and rivers that eventually take the water back to the ocean.

Percolation:
Surface water moves downwards, or *percolates*, through cracks, joints and pores in soil and rocks.

Ground water:
Much water is stored in the earth, occupying pores, cavities, cracks and other spaces in the crustal rocks and soil.

Water table:
The water table marks the change in the ground water zone between the zone of aeration, where some pores are open, and the underlying zone of saturation, in which water fills all the spaces in the soil and rocks.

The sun-powered cycle

The endless circulation of water from the atmosphere to the earth and its return to the atmosphere through condensation, precipitation, evaporation and transpiration is called the hydrologic cycle (see diagram).

The hydrologic cycle is at the heart of climate; it is the prime mover of solar energy around the globe. Without the hydrologic cycle, the tropics would remain unbearably hot, and the temperate zones eternally cold. It distributes the available heat and makes large parts of the globe livable.

Heating of the ocean water by the sun is the key process that keeps the hydrologic cycle in motion. Water evaporates, then falls as precipitation in the form of rain, hail, snow, sleet or drizzle. On its way to earth some precipitation may evaporate or, when it falls over land, be intercepted by vegetation before reaching the ground. The precipitation that reaches land rejoins the cycle in three different ways:

- Evaporation/transpiration—On average, as much as 40% of precipitation in Canada is evaporated or transpired.
- Percolation into the ground—Water moves downward through cracks and pores in soil and rocks to the water table. Water can move back up by capillary action or it can move horizontally under the earth's surface until it re-enters a surface water system.
- Surface runoff—Water runs across the land into nearby streams and lakes; the steeper the land and the less porous the soil, the greater the runoff. Rivers join each other and eventually form one major river that carries all of the subbasins' runoff into the ocean.

Although the hydrologic cycle balances what goes up with what comes down, one phase of the cycle is "frozen" in the colder regions during the winter season. During the Canadian winter, for example, most of the precipitation is simply stored as snow or ice on the ground. Later, during the spring melt, huge quantities of water are released, which explains our heavy spring runoff and flooding.

Diving beneath the surface

This Fact Sheet has been an introduction to the magic of water, its physical properties, and its ceaseless movement throughout the hydrologic cycle. To dive deeper into the subject of water and discover more about its role in the environment and its importance to mankind, consult the other fact sheets in this series.

Please write or call:
Editorial and Publications Division
Inland Waters Directorate
Environment Canada
Ottawa, Ontario
K1A 0H3
(819) 997-2601

Disponible en français sur demande

Published by authority of the Minister of the Environment

Cat. No. En 37-81/1-1988E
ISBN 0-662-16068-1