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EARTH'S OLDEST WATER

A record for the oldest water found on Earth was set in 2013 as researchers found several kilometers deep in a Canadian mine that produces copper, zinc and silver. The water was found bubbling up from a shaft, rather than trapped in solid rock (as is usually the case), and estimated to be between 1.5 and 2.0 billion years old. Considering that scientists place the planetary age at about 4.5 billion years, this water was probably produce and trapped in the Earth's crust as it cooled and could support life. Traces of sulfate and other simple ions in the freshwater suggest that ancient microbes were present and producing fluids over geologic timescales. By comparison, perhaps the world's oldest fossils (tube worms) may have been formed almost 4.3 billion years ago near thermal vents on the ocean floor, where seawater (comprising the entire planet's surface) and nutrient-rich magma were mixed.

DEUTERIUM

Water is composed of two atoms, hydrogen and oxygen, that exist in several varieties depending on the number of neutrons in their nucleus. These "isotopes" are present in water at ratios that reflect its source, its planetary journey and its interactions with earthly life forms. Deuterium is a stable (non-radioactive) isotope that represents only 0.02% of the hydrogen in water and was likely formed early in the universe's history. Because the lighter and more common isotope of hydrogen is preferentially utilized by biological systems, low-deuterium drinking water has been used to treat specific health issues in humans. By contrast, deuterium-rich water is preferred in nuclear fission reactors because it more effectively slows down the reactions. Recently, an ultra-dense form of deuterium has been created that can serve as fuel for the safer nuclear fusion reactors, which produce only helium and hydrogen as byproducts.

NUISANCE FLOODS

The term "nuisance flooding" is being used to describe that caused by high tides and routine rainfall events with the accompanying waves along coastal areas of the southeastern USA and elsewhere in the world. The causes of this flooding have been attributed to the combination of land subsidence and sea level rise. Whereas global climate change and sea level rise are now well correlated, it turns out that over-pumping groundwater aquifers and storing water behind dams results in a slight subsidence of the surrounding land. The land only subsides a few millimeters per year, but the cumulative effect on regions with elevations just above sea level is enough to cause chronic flooding (exclusive of major storm events). Since the beginning of the industrial age, humans have engaged in activities that redistribute water on the surface of the planet, affecting everything from watershed dynamics to the spin of the earth.

WATER COMPUTER

The digital age is dependent on a variety of otherwise inert materials such as silicon dioxide (quartz) and may soon turn to black phosphorus or carbon nanotubes to design computers of the future. Water is a substance one rarely associates with computing, although bioengineers have now designed a computer that utilizes synchronized droplets of water as bits of information within a magnetic field that determines the direction of movement and interactions of the droplets. A water computer typically takes advantage of so-called microfluidics, whereby nitrogen bubbles or magnetics direct the flow of water through tiny tubes. The direction of flow then transmits information. Although water computers cannot compete with their conventional counterparts in terms of speed, the former have an advantage of controlling matter so they can be used in the laboratory to control and automate experiments.

PLASTIC RIVERS

When one thinks of plastic trash, images of used water bottles, fishing nets and packaging are likely the most common images; however, large plastics are eventually broken up into much smaller fragments, or microplastics, that are the most dangerous to aquatic and marine organisms because they are mistaken for food and ingested. Surprisingly, most ocean plastics are introduced by ten of the major rivers in Asia and Africa (e.g., Nile, Yangtze, Ganges), which can deliver up to 3 million tons of plastic per year. In an effort to remediate the infamous Pacific Garbage Patch, an almost 700-meter long boom was towed offshore from San Francisco. The tube has a 3-meter skirt that allows it to be propelled by the wind in corralling surface plastics, which are then collected by a vessel and returned for recycling. While questions remain about the boom's efficacy, so do concerns about plastics that are too dense to float.

MARTIAN WATER

That liquid water may have been a surface feature of Mars in the distant past is a hypothesis that has been around for a long time. It is based on water-related minerals present in soils and on large-scale geological structures observed in various regions of the planet. Data collected from low-frequency radar now suggest that there may be actual liquid water underlying Mars' south pole; however, the results can be interpreted in a number of ways. For instance, the water may be solid (as ice) instead of liquid and the data could also indicate a solid form of carbon dioxide (i.e., dry ice) rather than water. Even if liquid water exists beneath the pole, it may not be present as an earth-type groundwater aquifer because of its depth (almost two kilometers beneath the surface) and bottom temperatures (as low as -70° C). Of course, possible liquid water on Mars energizes the search for earth-like life forms.

DEAD ZONES

News that extensive plots of bottom sediments in the Gulf of Mexico were essentially devoid of any marine life brought the topic of dead zones to the public's attention; however, this is a worldwide issue. Nutrients delivered by the Mississippi River from agricultural runoff along its course initiated massive blooms of marine algae that eventually died and sank to the bottom of the Gulf, where microbes then exhausted the available dissolved oxygen in decomposing algae. While periods of so-called hypoxia have apparently occurred sporadically in the geologic past, the mass of fertilizers and sewage reaching today's oceans has drastically increased the areal extent of dead zones. The prevalence of dead zones in semi-enclosed water bodies such as the Baltic Sea are even greater, affecting commercial fisheries and driving key species into suboptimal habitats or to local extinction.

CAPTURING WATER

In a previous insight, the topics of rainwater harvesting and green roof capturing were briefly discussed as alternative to augmenting freshwater supplies via desalination and other energy-intensive practices. Both rainwater harvesting and green roofs utilized catchments to reduce the volume of runoff diverted into stormwater drainage systems. Whereas the fraction of precipitation diverted from surface runoff by harvesting varies (<10% to almost 60%) depending on weather and site conditions, total and peak flows are reduced. Green roofs reduce surface runoff by as much as 90% and delay peak flows. Potential water quality issues (nutrients as nitrogen and phosphorus) depend upon substrate composition, geotextile type and plant species. By contrast, conventional urban runoff often contains pathogens, organic pollutants, metals and sometimes higher nutrient levels than green roofs.

STRUCTURE OF SEAWATER

Whereas the molecular structure of pure and fresh waters is relatively well described, the very high concentration of salts in seawater has precluded an accurate description of its structure until recently. Marine chemists have now determined that about 80% of seawater (in a temperature range of 0-40° C) assumes a hydrogen-bonded form, as represented by a pentamer that is characteristic of its tetrahedral connections to neighboring molecules. Less than 20% of seawater is present as individual H_2O molecules and about 6% comprises the solvation envelopes surrounding salts (ions) in seawater. The solvating water molecules are electrostatically bound to the ions but are not fully hydrogen bonded to other water molecules. Seawater's predominant hydrogen-bonded molecular network permits it to flow and facilitate the chemical reactions that are essential to marine ecosystems.

WATERY ASTEROIDS

Water is a well-described component of extraterrestrial bodies such as comets and other planets; however, its presence on asteroids is less familiar. Researchers estimate that as many as 80 asteroids (greater than a kilometer in diameter) now orbit near the Earth and are easier to access than the moon. These near-Earth asteroids may contain as much as 1200 billion liters of water, most of which is present as components of minerals such as iron oxide. How much of Earth's water was contributed by these asteroid minerals is unknown, but the prospect of mining this water in outer space has been suggested as an option for thirsty space travellers and for making propellants required by satellites. This finding further exemplifies the extent to which water's ubiquity in the solar system has been underestimated in its various phases and forms (e.g., solid, liquid, vapor, amorphous, mineral-bound).

OCEANIC PUMICE RAFT

A novel type of raft has been observed traveling westward in the South Pacific from somewhere near the island nation of Tonga toward Australia's Great Barrier Reef. The raft is composed of gray pumice stones that vary in size from a marble to a basketball and, collectively, occupy an area of about 60 square miles. Pumice is a relatively lightweight volcanic rock that was produced by an underwater volcano, which has also left its telltale odor of sulfur on the raft. Whereas the raft is an oddity for mariners sailing through it, scientists anticipate that it might be a boon for the Reef when it arrives after about a year's sea journey because it will be covered with a host of marine organisms. The attached barnacles, corals, algae, crabs and worms could assist in replenishing the species diversity than has declined over the last few decades as a result of climate change, pollution, overfishing and other factors.

NATURAL WATER TREATMENT

Treating water and wastewater in the postmodern era generally involves the use of man-made chemicals and materials; however, they often pose hazards associated with their production or application. An earlier insight noted that green chemistry represents a effort to replace such chemicals and materials with more natural alternatives. Coagulants such as aluminum sulfate and ferric chloride are used to remove dissolved and particulate impurities in water; however, research indicates that extracts from lentils (a common food) are cheaper, more effective, less toxic and produce a smaller volume of sludge than the conventional alternatives. Similarly, a very thin slice of porous wood can desalinate seawater using less pore pressure and thermal energy than is typically required for polymer membranes that are derived from plastics and pose a disposal issue when spent.

WATER, MOSQUITOES & BLOOD

The potential for mosquitos to transmit viral diseases to humans (e.g., dengue, Zika) is well known, as is the requirement for female mosquitoes to lay their eggs in freshwater following a blood meal. What was not known until recently is why the mosquito species (*Aedes aegypti*) that carries these viruses had such a preference for biting humans, rather than other animals from which they could obtain blood. It seems that at least some of the mosquito's preference for human blood is related to ancient people's storing water—especially in regions characterized by long dry seasons. Storing water in uncovered containers created an evolutionary pressure for mosquitoes to bite humans because people were most closely associated with a reliable place for females to lay their eggs. Hence, this mosquito's preference for human blood is actually a result of its reliance on a source of surface water.

WASTEWATER'S JOURNEY

Domestic wastewater is increasing utilized worldwide to irrigate crops destined for human consumption. Beyond the potential dangers of ingesting the food, there is a question of where the wastewater goes after it is applied to the soil. It turns out that the chemical and, depending on the level of treatment, microbial components often reach groundwater and can end up in drinking water wells. Industrial wastewater is too toxic or difficult to treat for use on food crops and is, instead, pumped into non-potable or saline aquifers via injection wells. Even if injection wells are intact and do not release wastewater into shallower water-bearing zones, they can still create problems. For instance, oilfield wastes trigger minor earthquakes if the fluids reach fault systems in the subsurface. Scientists speculate that as oil-laden wastewaters sink to even greater depths, the chance for larger earthquakes increases.