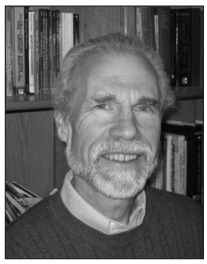
BREAKING THROUGH EDITORIAL



Infinitely Mysterious Water

Bill Zebuhr

Probably more has been written about water than any substance on earth and it is constantly being studied, provoking more discussion. It can be viewed on a macro level where vast quantities of water are involved that shape the earth by motion and shear weight: whole cities and hundreds of thousands of people can be wiped out in a massive flood; whole cities can be supplied with power by letting gravity enable vast quantities of water to flow through massive turbines; snow accumulating for tens of thousands of years piles up thousands of cubic miles of ice that can hang over the future earth like a sword of Damocles. In the opposite extreme, the bond angles of individual molecules are studied with the most advanced instruments to try to understand what makes water so unique and special.

Water is designed with extreme finesse to fulfill its incredibly varied role. Its behavior is so subtle that lifetimes are spent trying to decipher single aspects of it. Water exists as a liquid in a very narrow range of temperature, yet that is where its influence is most important in that all known life exists making use of these liquid properties. It is the primary liquid on what would otherwise be a solid, dry and barren world. It is the major energy transfer medium and weather creator. The large heat of vaporization of water combined with the huge volumes evaporated and condensed each day is a major heat transfer mechanism which drives much of earth's climate. Billions of btus per day are absorbed on a typical square mile by the evaporation of liquid water into vapor which then releases that energy in the atmosphere as it condenses back to liquid or even more if it then freezes to snow. Wind can drive that package of transferred energy over large distances to moderate temperatures across the earth.

Water enables life and then creates a climate where life can survive. The synergy is so good that it seems fundamentally necessary and might have to exist at least to some degree on any planet containing large amounts of life. At this point we are not certain that water is essential for life but we do not know of nor have we conceived of any intelligent life without water. Before exploration of other planets, we could imagine that earth was unique in its vast quantities of water and that life might be unique to earth but now we know of several planets and moons that contain water and realize that it may exist on millions of planets in the universe. This is an argument for the necessity of water for life since water itself may be common and there would be no "need" to invent a life form that was dependent on another enabling substance.

Water is an important part of manmade structures where cement has water as an essential ingredient and wood is used in large quantities. Large quantities are used in manufacturing to make almost everything from steel to semiconductors. Making integrated circuits on a 300 mm wafer requires about 2200 gallons of water and about 1500 gallons of that is ultra-pure water. Creation of ultra-pure water requires almost twice the desired quantity to start the purification process. Often the use of water leaves it contaminated, requiring disposal or treatment to clean it. If disposed it is tacitly assumed that nature will eventually clean it. That is usually the case but sometimes it can take centuries to do it and in many cases so much waste is created that man-made systems are required to clean it.

Cleaning water is a major industry ranging from municipal water treatment plants processing millions of gallons per hour to laboratory distillers taking hours to process one gallon. Processes include gravity separation, filtration in many forms, chemical and electrochemical cleaning and distillation. The water molecule itself aids in this process because of its small size and light weight. In a simple sand filter the molecular size is not important but in reverse osmosis it is critical because contaminants of molecular size are being removed. In distillation where water molecules are removed by boiling, preferably at just above the boiling point, the water molecules are released into steam by the kinetic energy of molecular motion that preferentially removes the water vs. heavier contaminants. One contaminate molecule per billion water molecules can be removed this way.

By far the largest water cleaning and recycling system on earth is nature, which uses many different processes including biological processes and combinations of processes, on a very large scale. Getting rid of a 50 ton dead whale is an ugly problem from our point of view but we can be grateful that nature has it all figured out and well developed. As the carcass sinks to the bottom of the ocean, which may be three miles down or more, and takes weeks, it is devoured by scavengers from large fish to bacteria and plants, with different processes taking over as the depth increases. Eventually the bones wind up on the bottom and everything else has turned into some other life form, water, dissolved minerals or gas.

The ultimate recycling system on earth is distillation,

where water is evaporated and pure water molecules rise from a water surface or are transpired from plants, and then condense and fall as rain. The rain can pick up contaminates from the air but usually not much.

This complex and life-enabling, self-cleaning process requires a balance of needs and resources that has developed over millions of years on earth but now is threatened by the overwhelming dominance of mankind, who is now the top predator and polluter—with no end in sight. This has been seriously discussed since Malthus published *An Essay on the Principle of Population* on population growth vs. resources in 1798. Water is central to the issue. In 1798 the concerns were mostly food and food production has easily kept up with population, although at a great cost. Water pollution then concerned very local supplies, not the entire world. The threat that Malthus discussed is still real in some form, but much more complicated. We now dispose of highly contaminated water routinely by putting it down deep wells that are supposed to separate it from aquifers and the ocean is treated as a vast dumping ground. This and other practices are risky and are done for the ability to burn another 50,000 gallons of fuel to transport crowds of people to another climate change meeting.

The fundamental problems are not now technical, they are political and the whole situation is exacerbated by a continual focus on one war or another over human-made problems that in theory are imaginary or simply stated to exist to justify an action motivated by power. However, if we continue on the current path a real war could start over water.

In view of the overwhelming importance and presence of water and that we are made up of about two-thirds water, it is remarkable that we do not understand major aspects of its interactions with us and the world. This is in part because our general understanding of the physical world is less than what most think it is and partly because water is a more complex and anomalous material than we generally consider it to be because of its huge role in the environment and biology.

In this issue of *Infinite Energy*, we point out some of the interesting and potentially very important features of water, many of which are not commonly known and few are well understood.

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