

---

# A Bag of Water

Module 3 • i2P • H2O Tour

---



“Water is fundamental for life and health. The human right to water is indispensable for leading a healthy life in human dignity. It is a pre-requisite to the realization of all other human rights.”

The United Nations Committee on Economic, Cultural and Social Rights  
Environment News Service, 27 Nov 2002



## BADWATER

The Badwater Ultra-marathon (see: [Badwater](#)) is considered one of the most difficult foot races on Earth. It involves running 135 miles through the searing July heat of California’s Death Valley on a course that leads through a number of mountain passes. A number of years ago Ray Zahab ran the Badwater. He was confident he could handle the course after a recent and successful 333 km run nonstop across the burning Nigerian desert. The Badwater started well but after 75 kilometers, quite suddenly, Ray began to feel woozy. Half a kilometer later he stopped to pee and discovered that his urine was the color of cola. Something was terribly wrong. The next thing Ray knew he was lying on his back with terrible abdominal cramps and leg spasms, completely unable to move, let alone run. He became delirious, and remembers little of the next few hours.

What happened to Ray?



Figure 1: Badwater Basin in Death Valley California (Source: Wikimedia)

## BODY OF WATER

The body is made up of many different systems, all of which require water in order to function. The human body needs so much water that 60% of the body of adult males and 55% of the body of adult females *is* water. Water makes up 99% of lean muscle tissue, 70% of blood, 10% of body fat and 22% of bone; even the skin contains water. Two-thirds of water in

he body (40% of overall body weight) can be found within cells (intracellularly) and the remaining 1/3 of water in the body (20% of overall body weight) can be found outside of cells (extracellularly).

#### WHAT DOES WATER DO IN THE BODY?

We have so much water in our bodies because it serves many important functions. One of the most important functions of water in the body is called *thermoregulation*, which is the regulation of body temperature. When a runner such as Ray goes on an adventure the muscles in their body are hard at work, and generate heat as they power the body forward. The body produces sweat to help regulate the body temperature. When the sweat evaporates from the skin - a process called *evaporative cooling* - the temperature of the body is lowered. When a runner exercises in hot conditions they will be at greater risk of overheating and thus will sweat more to lose more heat. That is why when an athlete like Ray exerts themselves in hot conditions, like the Badwater Ultra-marathon, they will require a great deal of water not to become dehydrated.

#### Student Exercise

Assume two people were the same height (5' 10") but one weighed twice as much as the other (300 vs 150 lbs). If they are doing the same amount of exercise and were cooling their bodies by sweating, would they need to produce the same amount of sweat?

If you need help answering this see: [Surface to Volume](#)

Water serves many functions beyond thermoregulation, such as helping to digest food and transport nutrients. Water is the basis of saliva, which has enzymes to help break down food so that minerals and nutrients can be released and absorbed by the body. Once in the bloodstream or the cells of the body, water supports *catabolism*, the process of taking larger compounds like protein and carbohydrates, and breaking them into smaller molecules like amino acids and glucose for fuel and energy. Fats, amino acids, glucose, minerals and water-soluble vitamins (like B vitamins and Vitamin C) are thereby absorbed by the blood stream, which is 70% water, to be distributed throughout the body. Water is also an important component of *anabolism*, the process of building larger molecules in order to store fuels. The sum total of the catabolism and anabolism of substances in your body is your *metabolism*.

#### Definition: Metabolism

Metabolism is the set of chemical reactions that happen in living organisms to maintain life.

In addition to helping break down, transport and store nutrients, water can also remove toxins from the body through perspiration, urination and defecation. Finally, water can help lubricate and cushion joints and organs.

#### HOW MUCH WATER IS ENOUGH?

The body is a dynamic system where the balance of water changes as water comes in and goes out. An average person needs about 64 oz (2 liters) of water per day, but this can vary depending on variables such as body size and shape, weight, underlying diseases (such as diabetes, or kidney disease) and the ambient temperature. In addition the health, or integrity of your skin can influence your ability to regulate your water balance. If you have a burn, or other skin conditions, you can lose a great deal of water. In this way the human body is a veritable 'bag of water' with the skin being the lining of the bag. If the lining of the bag is weak or has holes in it, the water can leak out. Lastly activity level influences the amount of daily water you require. If you exercise, particularly in a hot or humid environments then you will need more water. Ray will require more water to run in Tunisia than he would if he were relaxing, reading this module in Tunisia.

#### HOW IS WATER LOST?

The human body carefully regulates its water content because imbalances in water content can lead to severe illness and death. There are a host of mechanisms in the body to regulate water levels but the organ with the main responsibility is the kidney. Kidneys have the ability to excrete more or less water in the form of urine. When the body becomes very dry the kidneys will concentrate urine (decrease water content) so that the urine becomes very dark. Conversely, if you drink a great deal of water you will urinate a lot and your urine will be very clear (high water content). There are some



Figure 1: Lamb Kidneys (Source: Rainer Zenz)

diseases, like diabetes, that hamper the kidneys water regulation which can lead to serious illness.

The body can lose water in many ways, the most important pathways being through the kidneys and the lungs. Water is lost through the lungs as water vapor when people breath out. Additional water can be lost with prolonged exposure to dry air - such as when flying - or through crying. If you are sick, water can be lost through vomiting or diarrhea and if you are injured water can be lost through blood loss or burns. Finally, the use of drugs such alcohol, caffeine and amphetamines can cause kidneys to produce too much urine and result in water loss.

Statistically the most dangerous cause of water loss in the world is diarrhea. The illness is rarely a concern for individuals in developed countries (where treatment is available), but in underdeveloped countries, 1.81 million people die annually from diarrheal disease (6.9% of all deaths in the world); 1.5 million of these deaths are children. In some cases diarrhea can be prevented with a vaccination, or with hygiene interventions such as proper hand washing. In spite of these seemingly simple interventions, it is estimated that 88% of diarrheal death worldwide is the result of contaminated (disease bearing)

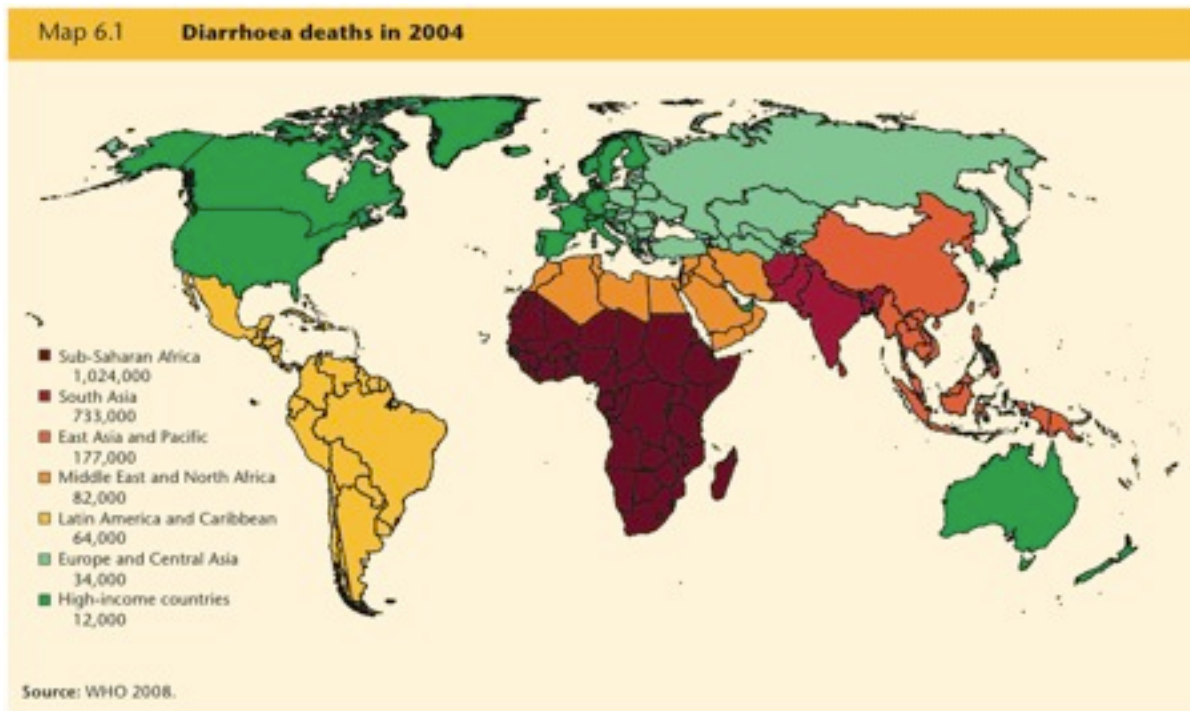


Figure 1: Death rates from diarrhea 2004, world (source: World Health Organization).

water in poor countries, where even simple treatments for diarrhea, such as zinc supplements and oral rehydration therapy are unavailable.

#### DEHYDRATION

Having less water than your body needs is a state called *dehydration*, and even low levels of dehydration can have negative effects on your body and brain function (cognition). The effects of dehydration can become noticeable with as little as a 2% decrease in water volume; a loss of 2.5% of water volume can result in a 25% loss of efficiency. Symptoms of mild dehydration include headaches, dry mouth, thirst, decreased urine output, dark urine, fatigue, irritability, decreased blood pressure and dizziness or fainting. Individuals with moderate to severe dehydration may have extreme

**TABLE 1:** ESTIMATE IN DAYS OF HUMAN SURVIVAL AT VARYING TEMPERATURE AND WATER INTAKE

| Max Daily Temperature | Number of Days in the Shade |                      |                         |                         |                          |                              |
|-----------------------|-----------------------------|----------------------|-------------------------|-------------------------|--------------------------|------------------------------|
|                       | No Water                    | 1 Quart<br>.95 Liter | 2 Quarts<br>1.90 Liters | 4 Quarts<br>3.79 Liters | 10 Quarts<br>9.46 Liters | 20 Quarts<br>18.93<br>Liters |
| <b>120 F / 48.9 C</b> | 2                           | 2                    | 2                       | 2.5                     | 3                        | 4.5                          |
| <b>110 F / 43.3 C</b> | 3                           | 3                    | 3.5                     | 4                       | 5                        | 7                            |
| <b>100 F / 37.8 C</b> | 5                           | 5.5                  | 6                       | 7                       | 9.5                      | 13.5                         |
| <b>90 F / 32.2 C</b>  | 7                           | 8                    | 9                       | 10.5                    | 15                       | 23                           |
| <b>80 F / 26.7 C</b>  | 9                           | 10                   | 11                      | 13                      | 19                       | 29                           |
| <b>70 F / 21.1 C</b>  | 10                          | 11                   | 12                      | 14                      | 20.5                     | 32                           |
| <b>60 F / 15.6 C</b>  | 10                          | 11                   | 12                      | 14                      | 21                       | 32                           |
| <b>50 F / 10.0 C</b>  | 10                          | 11                   | 12                      | 14.5                    | 21                       | 32                           |

Source: [Survival Topics](#)

lethargy, seizures, fainting, and sunken eyes. When an individual becomes dehydrated, they have less fluid volume (plasma) in their blood which means that their blood is thicker than usual. Because their blood is thicker they may have decreased blood pressure and their breathing may increase to compensate. Water loss greater than 15% can be fatal, but you can lose as much as 10% of your body weight through dehydration without experiencing long-term consequences.

Athletes are particularly susceptible to dehydration and their athletic performance may decrease by 30% even when slightly dehydrated. If Ray and the team in Tunisia become dehydrated by even a small amount, it could impair their speed and their ability to concentrate and make important decisions. Other symptoms that athletes may have

when they are dehydrated include flushing, decreased endurance, a rapid heart rate, elevated body temperature and a rapid onset of fatigue. Consequently athletes must be careful to drink a source of water or a sports drink to replenish fluids and electrolytes that have been lost through sweat.

#### TOO MUCH WATER

Dehydration can be fatal, but so can drinking too much water. There is a condition called polydipsia (derived from the Greek words “polys” (much, many) and “dipsa” (thirst)) that causes those that suffer from it to drink excessive amounts of water. This condition is present in individuals with mental disorders (some believe that it is part of the psychiatric illness, others believe that it is a side effect from medications used to treat the psychiatric illness). Patients may drink so much water that their kidneys are unable to process the fluid and they may gain weight due to fluid retention. This condition can be life threatening if not managed: when excess water dilutes salt in the body it can cause seizures and cardiac arrest.

#### BACK TO BADWATER

So let us return to Badwater where we left Ray delirious and unable to move. He became so confused that he lost all memory of a period of a few hours. His next memory was waking in a medical tent where attendants were urging him to drink fluid. In total he took in 5 liters of rehydration fluid (water and salts) over a short period of time, but nonetheless remained incapable of running. Although his race was done, he fortunately recovered fully.

This incident points out how easy it is to become dehydrated and how rapidly the effects can appear. In retrospect Ray acknowledges he kept putting off grabbing a drink because he was worried about wasting time. He went much too far in the intense heat without replenishing the water and salt he lost through sweating, water vapor from his lungs and urination. His kidneys tried to help him by concentrating his urine, but there is a limit to their capacity and he ultimately developed symptoms of marked dehydration.

Since then Ray is very respectful of the water balance of his body and this has never recurred. A lesson hard won.

