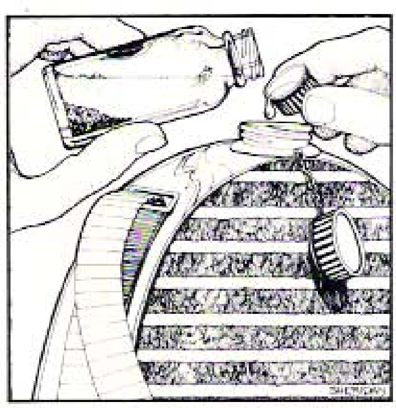
A Simple, Safe Method of Water Purification For Backpackers

ARTICLE BY FREDRICK H. KAHN AND BARBARA R. VISSCHER

1 The water purification kit consists of a one-ounce clear glass bottle with a hard plastic cap and 4 to 8 grams of USP-grade resublimed iodine—iodine crystals. Since iodine in large quantities is a poison, you may need a doctor's prescription to get it at your pharmacy. Eight grams costs about $2.00.

2 When water needs to be treated, fill the bottle with water, cap it, and shake it vigorously for 30 to 60 seconds. Shaking will cause some iodine from the crystals to be dissolved in the water. The amount of iodine that will be dissolved depends on the temperature of the water (see table).

3 What is used to disinfect the drinking water is this saturated iodine solution, not the crystals themselves. So hold the bottle upright for a few moments until the iodine crystals fall to the bottom. The one-ounce bottle holds 30 cc's altogether, and you can use the cap to measure the right amount.



4 Carefully pour the correct amount of iodine solution into a liter (a little more than a quart) of water. Then let the treated water sit until the iodine disinfects it. If you can wait, adding less iodine and letting the treated water stand longer will produce the same effect, and the water will taste better.

That clear, cold mountain stream is not as pure as you think. And that Halazone you've been carrying in your pack probably won't work. Do you have to risk giardiasis, dysentery, or some other disease? Not necessarily. Use iodine . . .

IT HAS ALWAYS BEEN ASSUMED that mountain streams were pure. With improved surveillance it is now known that most streams of the United States are polluted. Reliable data on the incidence of waterborne disease among hikers and backpackers are unavailable, yet potentially waterborne diseases including Salmonella infections, amoebic dysentery, giardiasis and infectious hepatitis are commonly observed among travelers returning from abroad and from remote areas of the United States.

The authors' interest in water disinfection was sharpened when they acquired giardiasis after drinking from a partly frozen stream on the Long Valley trail to Mount San Jacinto in California, in early May, 1971. Human habitation was sparse, and snow covered the ground. Cold weather, however, is no protection from intestinal parasitism and may actually present a problem in water purification, as will be explained below.

A water disinfectant must be able to kill the hardiest organisms, especially amoebic cysts and enteroviruses, the most resistant to disinfection of the pathogenic microorganisms. At the same time, the toxicity of the chemical must be very low. A water disinfectant for the traveler presents special requirements which are of less impor-

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tance to a sanitary engineer. These include simplicity, effectiveness in the presence of nitrogenous pollutants, rapidity of antimicrobial action over a wide pH range, and immediate palatability. The backpacker will, of course, also demand light weight.

How Much Saturated Iodine Solution You Add Depends on the Temperature.

The amount of iodine that will go into solution in your one-ounce bottle depends on the temperature of the water. The following quantities of nearly saturated iodine solution will yield an iodine concentration of four parts per million when added to one liter of water.

Temperature	Volume	Concentration	Capfuls*
3°C (37°F)	20.0 cc	200 ppm.	8
20°C (68°F)	13.0 cc	300 ppm.	5+
25°C (77°F)	12.5 cc	320 ppm.	5
40°C (104°F)	10.0 cc	400 ppm.	4

*Assuming a capful of standard 1 ounce glass bottle is 2½ cc.

DURING WORLD WAR II, Halazone (p-dichlorosulfamoyl benzoic acid) was issued for individual use when other forms of water treatment were not available. Though Halazone produced potable water in the absence of heavy contamination, its efficacy in treating cold, heavily polluted water containing resistant forms such as viruses and amoebic cysts was seriously questioned. In 1942, at the request of the armed forces, investigators at Harvard University initiated a search for a more dependable technique of water sterilization. Their study recommended the use of iodine for treatment of small quantities of water. A technique for iodination was developed and adapted by the armed forces. Subsequent investigations confirm the superiority of iodination as a personal water germicide, yet Halazone continues to be widely used and is often the only commercially available agent.

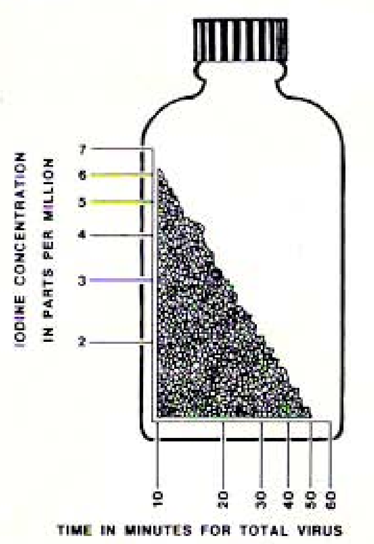
CHLORINATION BY HALAZONE in the recommended dose depends on the slow release of 2.8 parts per million (ppm) of free chlorine for immediate antimicrobial action. Chlorine under ideal conditions, namely a pH of 7 or lower (neutral or acidic water) and the absence of nitrogenous compounds, hydrolyzes to hypochlorous acid (HClO), an excellent germicide. But HClO is highly reactive and in the presence of such nitrogen-containing compounds as amino and ammonia ions, it is quickly converted to relatively inactive monochloramine. Moreover, above pH 7 (alkaline water) HClO hydrolyzes to the less active hypochlorite.

These two problems are solved in water purification plants by the practice of breakpoint chlorination, the application of sufficient chlorine to bind with the organic materials in the water while leaving a biocidal residual of free chlorine. But this technique requires continual testing and is impractical for rapid treatment of small quantities of water. The individual traveler must resort to simple chlorination, the practice of adding a fixed dose of chlorine compound to water of uncertain quality. Simple chlorination is unpredictable and may be useless against bacteria and enteroviruses when water is contaminated with organic material.

Additional disadvantages of Halazone are slow solubility and a short shelf life of five months when stored at 32°C. (89.6°F.). Potency is reduced 50 percent when stored at 40° to 50°C. (104° to 122°F.), the temperature range one might expect in an automobile glove compartment on a summer day. Halazone also loses 75 percent of its activity when exposed to air for two days.

IODINATION, IN CONTRAST, with a weak aqueous solution of 3 to 5 ppm of elemental iodine (I_2) will destroy amoebae and their cysts, bacteria and their spores, algae, and enteroviruses at 25°C. (77°F.) in 15 minutes or less (see chart). At near freezing (3°C., 37.4°F.) disinfection will require 20 to 30 minutes at the same concentration of iodine, since germicidal potency is roughly proportional to temperature. Elemental iodine does not react readily with ammonia and amino ions and therefore will remain an effective disinfectant in water polluted with nitrogenous wastes. Iodine is effective over a wide pH range, hydrolyzing at pH above 6 to hydroiodous acid, which is a faster viruicide than I_2.

Iodine Concentration vs. Time Required for Total Virus Destruction



Because the concentration of iodine is inversely proportional to the time required for disinfection, a lower concentration of iodine left in water for a longer period of time will have the same disinfection effect and make the treated water taste better. The virus that produced these figures is one of the hardiest, comparable to the infectious hepatitis virus.

Iodination can be accomplished in three ways. One method is the addition of eight drops of two percent tincture of iodine to a quart of water, but this results in water of less than acceptable palatability. A second is the addition of a tablet of Globaline (tetraglycine hydroperiodide) to a quart of water, releasing active iodine in a concentration of 8 ppm. The disadvantages of Globaline Tablets include a fixed, high concentration of iodine and a 33 percent loss of their initial activity when exposed to air for four days. The third method is the use of crystals of elemental iodine.

THE ONLY EQUIPMENT needed for iodination with crystalline iodine is a one-ounce clear glass bottle, with a leak-proof bakelite cap, containing 4 to 8 grams (or any small quantity) of USP grade resublimed iodine (I_2). The bottle is filled with water and capped, shaken vigorously for 30 to 60 seconds, then held upright for a few moments to permit the heavy iodine crystals (specific gravity 4.6) to fall to the bottom. *The iodine crystals are not to be used directly*. What is used is the *water* in the bottle, now a nearly saturated iodine solution. Disinfection is accomplished at 25°C. (77°F.) by the addition of 12½ cubic centimeters (cc) of this nearly saturated solution to one liter of water (1.06 quarts) to achieve a final concentration of 4 ppm iodine. Since the concentration of the saturated iodine solution varies with its temperature (see table), only 10 cc of iodine solution would be needed if the bottle were

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kept at body temperature. At near freezing, 20 cc of iodine solution would be used per liter. (The cap of the iodine bottle may serve as a measuring device.) After a contact time of 15 minutes, the water is disinfected. When more disinfected water is desired, the above steps can be repeated almost 1,000 times without replenishing the iodine crystals. The shelf life of crystalline iodine is unlimited.

Under usual circumstances, a 2 ppm iodine solution with a contact time of 40 minutes offers improved palatability and effective disinfection. If increased germicidal potency is necessary because the water is turbid, cold, or heavily contaminated, the concentration of the iodine solution could be increased to 8 ppm, with a contact time of 20 minutes. However, in the interest of palatability, one may prefer not to increase the concentration, but instead increase the contact time (see chart).

A clear glass bottle is recommended to permit observation of the iodine crystals. Plastic bottles of all types take on an opaque brown stain after long exposure to the working solution. Furthermore, plastic bottles tend to leak as one travels to high elevations and distort and crack on descent to low elevations.

The toxicity of iodine is remarkably low in the concentrations used for water disinfection. Only persons with a specific sensitivity to iodine, and perhaps those who have been treated for hyperthyroidism, risk any ill effects. The only danger of the iodination procedure is the inadvertent ingestion of iodine crystals, although an ounce of nearly saturated iodine solution would be harmless. No fatality from ingestion of less than 15 grams of iodine has been reported.

Chlorine, except when breakpoint chlorination is practiced, is an unreliable disinfectant. Iodination, on the other hand, rapidly inactivates the known human pathogens, including the enteroviruses which are the most resistant to disinfection. Iodination is effective over a wide pH range and in the presence of nitrogenous pollutants. There is a need among travelers and hikers for an effective, palatable water disinfectant with rapid action and long shelf life. The iodine disinfection method described above meets these requirements.