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Commentary

Use of Iodine for Water Disinfection: Iodine Toxicity and Maximum

Recommended Dose

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Iodine is an effective, simple, and cost-efficient means of water disinfection for people who vacation, travel, or work in areas where municipal water treatment is not reliable. However, there is considerable controversy about the maximum safe iodine dose and duration of use when iodine is ingested in excess of the recommended daily dietary amount. The major health effect of concern with excess iodine ingestion is thyroid disorders, primarily hypothyroidism with or without iodine-induced goiter. A review of the human trials on the safety of iodine ingestion indicates that neither the maximum recommended dietary dose (2 mg/day) nor the maximum recommended duration of use (3 weeks) has a firm basis. Rather than a clear threshold response level or a linear and temporal dose–response relationship between iodine intake and thyroid function, there appears to be marked individual sensitivity, often resulting from unmasking of underlying thyroid disease. The use of iodine for water disinfection requires a risk–benefit decision based on iodine's benefit as a disinfectant and the changes it induces in thyroid physiology. By using appropriate disinfection techniques and monitoring thyroid function, most people can use iodine for water treatment over a prolonged period of time. *Key words*: goiter, iodine, thyroid disorders, thyroid hormones, water purification, water supply. *Environ Health Perspect* 108:679–684 (2000). [Online 21 June 2000]

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Iodine is an essential nutrient for optimal thyroid function in adults and for fetal, infant, and child development. Dietary supplementation, generally via iodized salt but occasionally via iodinated water, has decreased goiter and hypothyroidism due to iodine deficiency in most of the world. Data from supplementation programs and elsewhere indicate that adults need to ingest at least 150–200 µg iodine per day (*1–3*). Hollowell et al. (*4*) reported that the average American intake of iodine is near optimal. Nonetheless, ingestion of iodine in excess of the recommended daily intake level is common because of iodine in dietary sources such as dairy, eggs, meat, bread, and seaweed, or that in pharmacologic sources such as the cardiac antiarrhythmic drug amiodarone. Excess iodine may also disrupt normal thyroid function, but the maximum safe level for long-term ingestion remains undetermined. Experts suggest that 1–2 mg/day is safe for most people, yet empiric evidence suggests that much higher amounts are usually tolerated without problems (*1,5*).

The use of iodine to improve the microbiologic quality of drinking water in areas without safe public sources of potable water also contributes iodine levels in excess of the recommended maximum daily intake. Field water treatment is a necessity for millions of travelers, campers, military troops, and people living and working in underdeveloped areas, in addition to entire populations in disaster and medical relief situations (*6*). We reviewed published data on the effects of consuming more than the daily recommended dose of iodine in an attempt to identify the maximum safe dose and duration of ingestion when iodine is used for water disinfection.

Iodine for Water Treatment

Iodine is a halogen, like chlorine, that exerts a biocidal effect through its chemical property as a strong oxidant. The active disinfectant species are elemental iodine and hypoiodous acid (*7,8*). Iodide has no disinfectant activity; however, iodine is rapidly converted to iodide in the stomach and absorbed into the blood. Water disinfection with halogens is a first-order chemical reaction: the primary variables are aqueous concentration of halogen and the time it is in contact with the microorganism (*9,10*). In addition, different classes of microorganisms vary in their susceptibility to halogens. Bacteria are very sensitive, viruses are intermediate, and protozoan cysts are more resistant. Doses of iodine below 1 mg/L are effective for bacteria within minutes; however, at this concentration, it would take many hours to kill *Giardia* cysts. Although low doses can be used in controlled situations, recommended levels of iodine for point-of-use water disinfection in unmonitored field situations are higher to allow for unanticipated reactions with organic contaminants (halogen demand) and to allow a relatively short contact time (*6*).

Iodine has several advantages over chlorine for field use—including greater chemical stability of the product and less reactivity with organic nitrogenous contaminants of residual concentrations in water—leaving higher free residual concentration in water and more acceptable taste in equipotent doses (*11,12*). Iodine is available in a variety of forms, including solutions (tincture of iodine, povidone, Lugol's, and saturated aqueous solution with iodine crystals), tablets, and iodine resins.

Iodine resins offer additional advantages for field use because the resins are an extremely stable form of iodine that can be incorporated into a wide range of filters and act as a demand disinfectant with limited dissolution in water (*13*). Little iodine is released into aqueous solution, however: as water passes through and microorganisms contact the resin, iodine is aided by electrostatic forces and binds to microorganisms. The residual iodine concentration with iodine resins is much less than concentrations from the recommended doses of tablet or liquid forms of iodine (Table 1). Iodine resin filters usually incorporate two additional stages: microfiltration to remove *Cryptosporidium* oocysts that are resistant to halogen disinfection, and granular activated charcoal to further reduce the concentration of iodine in effluent water.

Iodine has been used to ensure the safety of potable water since the 1940s, when the military developed a tablet formulation for use by troops in the field (*10*). Widespread use followed in the civilian population. There are no accurate figures for the number of civilian or military personnel who use iodine for water disinfection. A survey of manufacturers reveals that in 1998 approximately 60,000 iodine resin devices were sold for individual or small-group civilian use. In addition, the leading manufacturer sold more than 300,000 bottles of iodine tablets. This does not include iodine sold in other forms, such as tincture of iodine, povidone, or iodine crystals in aqueous solution.

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Abstract

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