U.S. Perchlorate Policy in Disarray

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After more than a decade of debate, perchlorate policy remains in disarray, with states like California and Massachusetts developing enforceable standards while federal agencies and scientists are still working to determine if perchlorate (salts derived from perchloric acid, HClO₄) poses a public health risk at the dietary exposure levels experienced by society. Pressure is growing for immediate national standards even before studies are completed to determine the relative dietary exposures and potential risks from perchlorate in water, fruit, vegetables, cereals, dairy products, wine, beer, and processed foods across the United States and from other parts of the world. The new majority in Congress has promised hearings and has already introduced perchlorate legislation, while government officials remind us that only a few of the foods that make up “typical” diets have been analyzed for perchlorate content, and variations by region can be significant.

Most of the legal and political focus continues to be centered on the major human contributions of perchlorate—such as releases of rocket fuel—to soil, water, and food, although the likely role of naturally occurring perchlorate deposits is gaining attention. Originally thought to only occur in the Atacama Desert of Chile, ancient perchlorate deposits have been tracked by geologists to many locations around the world, including western United States. The U.S. Geological Survey, for example, found natural perchlorate deposits that exceeded 1,000 parts per million (ppm) in several samples of minerals, including potash ore from New Mexico and Saskatchewan, Canada, playa crusts from Bolivia, and hanksite mineral from California. Other studies confirm that natural production of perchlorate has likely occurred for millennia in the atmosphere around the globe, falling with rain or snow, where it accumulated in the kelp of the oceans and many desert soils of the world. Today, natural perchlorate can be measured in wilderness rain, alpine snowfall, and in ancient groundwater aquifers, such as the Ogallala Aquifer. The perchlorate levels in temperate soils from natural sources are often low because it is leached into the subsoils or washed to rivers and oceans by periodic rainfall. But in arid regions of the world with suitable atmospheric and climatic conditions, the literature suggests that naturally produced perchlorate has accumulated in soils and plants for millennia.

At high enough concentrations, perchlorate competitively interferes with iodine uptake by the thyroid and disrupts that gland’s ability to regulate the body’s metabolism. As such, perchlorate is termed a “goitrogen,” named after the chronically swollen thyroid glands (goiters) that were a common affliction in parts of the United States in the late 1920s before iodized salt was available. Although the exposure levels that would cause actual adverse effects in young children, pregnant women, or the developing fetus are unknown, the very high dosages of potassium perchlorate (e.g., 900 mg/day for extended periods) used in medicine since the late 1950s to treat hyperthyroidism due to Graves’ Disease provide some understanding of the large range of perchlorate exposures that are well tolerated by adults. Keith W. Wenzel et al., Similar Effects of Thionamides Drugs and Perchlorate on Thyroid-Stimulating Immunoglobulins in Graves’ Disease: Evidence Against an Immunosuppressive Action of Thionamide Drugs, J. CLIN. ENDOCRINOL. METAB., 58:62–69 (1984). Today’s perchlorate policy debate, however, is centered on what assumptions should be used to determine a safe exposure level for the most sensitive subpopulations of society (young children, pregnant women, or the developing fetus) and is focused on exposure levels that are orders of magnitude below those therapeutic levels. Although it is likely that perchlorate has been an unnoticed part of our diet and lives for many generations, policymakers are grappling with the question of what are the hazards, if any, that sensitive subpopulation segments may face under normal dietary conditions. A few human clinical ingestion studies and several epidemiological studies form the current basis of data for our public policy discussions. Monte A. Greer and colleagues found that perchlorate ingestion of up to 240 ppm in drinking water (0.007 mg/kg-day) had no effect on the iodine uptake or thyroid function of adult volunteers. Monte A. Greer et al., Health Effects Assessment for Environmental Perchlorate Contamination: The Dose Response for Inhibition for Thyroidal Radioiodine Uptake in Humans, ENVIRON. HEALTH PERSPECTIVES, 110 (9): 927–937 (2002). The highest dosage administered (0.5 mg/kg-day or 17,500 ppm), a fraction of the therapeutic dose for Graves’ Disease, also had no effect on thyroid function but reduced iodine uptake by 67 percent. Although partial iodine uptake inhibition is not itself harmful, its avoidance has become the no-effect threshold of current scientific and regulatory debate. Massachusetts, for example, has promulgated a drinking water standard of 2.0 ppm.

Epidemiological studies designed to examine statistical associations between perchlorate exposures and human health suggest that perchlorate has been well tolerated by societies and subpopulations where iodine nutrition is adequate. Bert De Groef et al., Perochlorate Versus Other Environmental Sodium/Iodine Symporter Inhibitors: Potential Thyroid Health Effects, EUR. J. ENDOCRINOLOGY, 155: 17–25 (2006). Much less is known, however, about no-effect exposure thresholds for pregnant women and nursing infants under iodine-deficiency conditions, a small but potentially vulnerable segment of society. These are life stages when the maternal thyroid plays a critical role in producing

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the iodide-containing hormones that influence normal fetal and newborn development and metabolism. Adequate iodine nutrition obviates the effects of goitrogens, but significant iodine deficiency or prolonged impairment of thyroid function during sensitive life stages—either due to diet or high levels of competing ions like perchlorate—could result in adverse effects to the offspring that include delayed development and decreased learning capability.

Fortunately, significant iodine deficiency in the United States is likely to be a very rare occurrence. The literature suggests that to be iodine-deficient today, a person must deliberately avoid not just meat, fish and poultry, but also many processed foods, most dairy products, flavored cereals, commercial baked goods, iodized salt, and many iodine-containing multivitamins and dietary supplements. Foods with the highest iodine content, 54 to 450 µg per serving, include a cross-section of typical American cuisine: fruit-flavored cereals, chocolate milk and milk shakes, cheese pizza, cod/haddock, chicken pot pie, low-fat plain yogurt, macaroni and cheese, corn grits, homemade lasagna, white rice, pancakes, chicken noodle casserole, canned spaghetti in tomato sauce, low-fat milk, apple pie, fish sticks, chocolate pudding, and mashed potatoes. Jean A.T. Pennington et al., Composition of Core Foods in the U.S. Food Supply, 1982–1991, J. FOOD COMP. ANAL. 8:171–217 (1995); Cheryl Fields et al., Iodine-Deficient Vegetarians: A Hypothetical Perchlorate-Susceptible Population, Reg. TOX. & PHARMACOLOGY, 42:37–46 (2005).

However, at least one environmental group claims that perhaps one-third of women in the United States are deficient in iodine, and medical intervention would be needed to protect newborn babies from the effects of typical dietary perchlorate exposures (http://ewg.org/reports/thyroid/threat/). Its arguments are based on an interpretation of recently published data from an epidemiological study by the Center for Disease Control (CDC), in which urinary perchlorate and thyroid hormone levels in blood were characterized from more than 2,000 adolescent and adult men and women living in the United States. Benjamin C. Blount et al., Urinary Perchlorate and Thyroid Hormone Levels in Adolescent and Adult Men and Women Living in the United States, ENVIRON. HEALTH PERSPECTIVES, 114:1865–1871 (2006). The publication reported that thyroid function in women (but not men) who had levels of iodine in their urine below recommended sufficiency levels appeared to be affected by low levels of perchlorate—although even in these women thyroid function was still within the normal range. The environmental group held this publication up as evidence that perchlorate, but not other measured goitrogens studied (thiocyanate and nitrate), influenced thyroid function at low urinary levels of iodine is not explained. The ATA concluded that “the issues raised are important and additional study to resolve them should be pursued” (http://www.thyroid.org/professionals/publications/statements/06_12_13_perchlorate.html). Until key questions are resolved, it would be premature to base regulatory determinations on this one epidemiological study.

By definition, all goitrogens at some concentrations will affect normal thyroid function. The literature suggests that these levels of inhibition may change remarkably among individuals, depending on many factors including, among other things, what foods one eats, what the combined goitrogen level in the meal portions is, and how that level relates to the iodine levels of the foods eaten plus that stored by the individual. Effects of perchlorate at any given time result only from the incremental effect of iodine uptake inhibition above and beyond the normal inhibition already caused by the intake of these other inhibitors in the diet. Douglas Crawford-Brown et al., Intersubject Variability of Risk from Perchlorate in Community Water Supplies, ENVIRON. HEALTH PERSPECT., 114(7): 975–979 (2006). The CDC study probably examined the levels and effects of perchlorate, nitrate, and thiocyanate on thyroid function because they are the most common goitrogens in our diets. Although the relative potencies of nitrate and thiocyanate as dietary goitrogens are many times less than that of perchlorate (e.g., a 1.0 ppb perchlorate exposure is equivalent to about 150 to 200 ppb nitrate), they are naturally present at such high levels that their net effect is to eclipse that of perchlorate. The literature suggests that, of the total level of iodine-uptake inhibition that occurs from ingestion of food and water, less than 1 percent is due to the perchlorate present, with the balance due to the normal background of other inhibitors that occur in our typical diets. Bert De Groef et al., supra.

Public health officials and environmental regulators, therefore, face a dilemma: If these various iodine-uptake inhibitors have always been present in wholesome, balanced diets of nutritious foods, and the addition of perchlorate adds only a small, perhaps insignificant increment of additional goitrogen, what should the public health response of lawmakers be? If a typical luncheon salad contains more than 2,000 ppm (2,000,000 ppb) of nitrate (and perhaps a similar level of thiocyanate), representing exposure to a level of iodine-inhibition potency equivalent to at least 10 ppm (10,000 ppb) of perchlorate, how can exposures to a few ppb perchlorate in the drinking water or other beverage that accompanies the salad be considered a risk to the population or the most sensitive subgroups of it?

With so many natural goitrogens in what society has found to be a healthy, balanced diet of water, fruit, vegetables, cereals, dairy products, meats, and other protein sources, the fact that many of these same foods also supply essential iodine may help explain the rarity of adverse