IODINE

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Introduction

If you have ever looked carefully at your commercial container of salt sitting in the cupboard, then you have noticed that it is iodized. Have you ever wondered what that means, or why it is mentioned? The simple answer to these questions is that a form of the element, iodine, is added to the salt in order to keep you healthy. More complex is the underlying reason behind many different types of food fortifications: medical geology. According to medical geology, humans are linked with the natural processes of the Earth by requiring certain levels of particular elements and compounds to maintain optimal health. Thus, iodine is added to salt in order to supply enough iodine in your diet and satisfy the link between iodine and optimal health. In order to understand why iodine is important for humans to consume, I will examine iodine's chemical properties, where it occurs naturally, how it interacts in biological processes, its geologic properties, and the implications of this multidisciplinary analysis.

Chemical characteristics

Chemistry identifies iodine according to its chemical properties, such as the ability to react with other substances, physical properties at various temperatures, and color. Iodine---chemical symbol 'I'---is the name given to element 53 on the periodic table of elements. It is a nonmetallic element that belongs to Group 17/VIIA of the periodic table (the halogen group). The color of iodine in its gaseous state is violet, which gives iodine its name: it comes from the Greek word for violet ('iodes') [Atkins and Jones pp 592]. Iodine has many other known chemical and physical properties: atomic weight is 126.9045 grams, melting point is 113.7 ˚C, boiling point is 184.4 ˚C, and atomic radius is 133.3 pm [Atkins and Jones pp 592]. As a solid, which is its normal form (at 25 ˚C and 1 atm), iodine has a blue-black color and sublimes easily [Atkins and Jones pp 592]. When it is dissolved in organic solvents, it produces solutions having a variety of colors; starch is a common indicator for the presence of iodine in solution by causing a solution of iodine to change color [Atkins and Jones pp 592]. If iodine touches the skin of a person, lesions can occur; furthermore, iodine vapor is intensely irritating to the eyes and mucus membranes [Atkins and Jones pp 592]. Even though iodine can be harmful if it is carelessly handled, it still has many practical uses: silver iodide is used in photography, and it is combined with alcohol and used as a disinfectant for wounds [Atkins and Jones, pp 592].

Natural Occurrence

Where else does iodine exist outside of table salt? First of all, we encounter iodine in nature as iodide ions in brines and as an impurity in Chile saltpeter; Chile is the leading producer of iodine in the world (USGS 2). The main natural source of iodine is kelp: 2000 kg of seaweed produce about 1 kg of iodine [Atkins and Jones, pp 592]. In fact, Bernard Courtois is credited with the discovery of iodine when he “accidentally added concentrated sulfuric to the seaweed Fucus vesiculosus” [Fuge, pp 418]. What’s important to note is that Iodine is more naturally abundant near the sea; this fact will result in a link between iodine’s geology and biological consequences later on in the paper. In order to understand the link, I must first explain the biological role of iodine.

Essentiality of Iodine:

Iodine is an essential trace element, meaning that the human body needs iodine to function properly. Without enough of it, health problems can occur; with too much of it, toxic effects can appear. These observations result in a particular range in which iodine should be found in the body. According to Ron Fuge in *Essentials of Medical Geology*, the daily recommended dietary intake of iodine is estimated to be "110-130 μg/day for children under the age of 1, 90-120 μg/day for children aged 1-10, and 150 μg/day for adults and adolescents, with higher concentrations required during pregnancy and lactation" [Fuge, pp 426]. Humans need iodine because of the thyroid gland, which is located in the neck; anatomically, the thyroid gland consists of two lobes connected by a narrow isthmus, and it is composed of functional units called follicles [Lindh, pp 149]. The main function of the thyroid gland is to synthesize and store thyroid hormones: thyroxine (T_4) and 3,5,3´-triiodothyronine (T_3) [Lindh, pp 150]. Iodine's role in the thyroid gland is to provide the raw material for hormone synthesis [Lindh, pp 150]. In fact, iodine contributes to 65% of T_4 molecular size and 59% of T_3 molecular size [Lindh, pp 150]. Thyroid hormones are important for "normal growth and development"; they control "the metabolic activity of many tissues through influences on the metabolism of carbohydrates, proteins, lipids, vitamins, nucleic acids, and ions" [Bernal and DeGroot, pp124-125].

The amount of iodine in the thyroid is another important indicator of its essentiality; normal adult thyroid weighs 20-25g and contains 8-10mg of iodine [Cherian and Nordberg, pp 189]. Iodine is selectively concentrated by the thyroid gland in amounts adequate for hormone synthesis. Most ingested iodine is reduced in the gastrointestinal tract and absorbed almost completely; the remaining iodine is excreted in the urine [Lindh, pp 150]. Deiodinases help to recycle iodine within the thyroid gland [Gershengor, pp 99]. Thyroid-stimulating hormone (TSH) is the major regulator of thyroid function [Cunnane, pp 119]. In response to concentrations of thyroid hormone, the pituitary gland secretes thyroid-stimulating hormone (TSH) to regulate thyroid function [Cunane, pp 120]. An elevated serum TSH concentration indicates primary hypothyroidism; in contrast, decrease in TSH concentration reflects hyperthyroidism [Lindh, pp 151].

Effects of Iodine Deficiency

Hypothyroidism and hyperthyroidism are conditions caused by the amount of iodine in the body moving outside the range required for optimal health. Even though both conditions can occur, hypothyroidism is much more common in the world. Not consuming enough iodine can lead to Iodine Deficiency Disorders (I.D.D.). These disorders vary depending on the age of the person, but the two most common ones associated with iodine deficiency are goiter and cretinism. Goiter is a condition resulting from the thyroid gland becoming enlarged in an attempt to be more efficient at obtaining iodine, whereas cretinism is a condition resulting in mental deficiency [Fuge, pp 417]. How common is iodine deficiency? The answer is that in 1990, the U.N. and W.H.O. estimated that about 1 billion people are at risk for I.D.D. [Cherian and Nordberg, pp 189]. This statistic includes 211 million people with goiter, and 5.1 million people with cretinism [189]. In severely iodine deficiency areas, the inhabitants have a mean I.Q. loss of 13.5 points [Fuge, pp 417]. The loss in I.Q. points is an expected result of iodine deficiency: it "impairs at least two key aspects of lipid metabolism in the developing mammalian brain---ketogenesis for energy metabolism and myelin synthesis" [Cunnane, pp 129]. While the terrible effects of iodine deficiency are seen around the world, their causes have explanations: iodine deficiency is the result of many factors, the most important ones being geological and cultural.

Geological impact on Iodine Deficiency

Depending on a person's location around the world, the iodine content in the soil varies. Iodine is most abundant in the sea and along the seashore; as a person moves inland from the sea, the iodine concentration of the soil decreases, representing a negative correlation between distance from the sea and amount of iodine concentration in the soil [Fuge, pp 421]. Most geologists believe that little iodine in the secondary environment is derived from weathering of the lithosphere [Fuge, pp 418]. The result of these observations is that iodine deficiency disorders tend to be geographically defined, most common in high mountain ranges, rain shadow areas, and central continental regions; these affected regions correspond to a high occurrence of I.D.D. in the central regions of South America, Africa, and Asia [Fuge, pp 418]. Of course, these studies suggest that central regions of Western Europe and North America should be affected by I.D.D., and that island regions like New Guinea should not see cases of I.D.D. In contrast, the occurrence of I.D.D. is reversed for these areas; what accounts for these anomalies?

Cultural Effects on Iodine Deficiency Disorder

The answer is that the occurrence of I.D.D. is also influenced by culture. Two particular case studies reveal how the government and the interaction between different cultures can lead to I.D.D. in one country and not the other. The first case study looks at iodine deficiency in England during the 20th century; this is an example of culture helping to decrease I.D.D. cases. British research in the 1920s revealed that iodine supplementation improved livestock reproductive performance [Duncan and Scott, pp 250]. As a result of the research, English farmers fed more iodine to their cattle in order to increase their profits [Duncan and Scott pp 250]. At the same time, government policies lead to an increase in the consumption of milk throughout the country [Duncan and Scott, pp 250]. The result: endogenous infant mortality rates decreased as iodine intake increased [Duncan and Scott, pp 250]. English culture---scientific research, government policies, and English cultural practices---lead to a decrease in I.D.D. among the British population, even though iodine deficiency was widespread prior to the 20th century because inland soils were lacking proper amounts of iodine.

The other case study was completed by an anthropologist from Queens College: Georgeda Buchbinder. Her study involved a “recently located” tribe in New Guinea called the Maring. According to Buchbinder, endemic goiter and cretinism occurred in the Maring tribe as a result of cultural contact between the Maring and other cultures [Buchbinder, pp 106]. She noted that the only main source of iodine in the diet of the Maring was the salt that they locally manufactured by the sea [Buchbinder, pp 113]. After coming into contact with the outside world, non-iodized trade salt was substituted in their culture, resulting in a deficiency of iodine in their diet [Buchbinder, pp 114]. Buchbinder studied the Maring over many years, from the time when they were discovered by outsiders, up until the time when she concluded that the rise in goiter and cretinism in the Maring population was a direct result of cultural interaction. Both case studies by Duncan, Scott and Buchbinder show that I.D.D. can occur as a result of the culture in which a person is living. Furthermore, geological studies reveal that the geological occurrence of iodine in the soils around the world contributes to I.D.D. The important conclusion to make is that in order to properly study deficiencies and toxicities, the scientist needs to look at a multiplicity of factors that could be causing the particular illness in society.

Symptoms of Iodine Deficiency Disorder

Now that the main causes of I.D.D. have been examined, how do you know if you have it? First of all, goiter and cretinism are the two most easily recognizable signs of I.D.D. More experimental methods include measuring iodine content in the soil using certain reactive chemicals, potentiometry, and neutron activation analysis. The blood of a person suspected of having I.D.D. can be analyzed and compared against normal clinical values of iodine for healthy adults: urinary concentration should be greater than 1000 µg/L, serum T_4 concentration should be in the range of 60-100 µg/L, and serum TSH concentration should be in the range of 1-50 μg/L [Combs, pp 175]. For Americans, iodine concentration isn't usually monitored in the blood because the government has taken certain actions to prevent iodine deficiency in America.

Prevention of Iodine Deficiency

As mentioned in the end of the last paragraph, there are methods that can prevent iodine deficiency. The first step in preventing iodine deficiency is accepting the fact that iodine is an essential trace element; both deficiencies and toxicities can create major health problems. Once a society recognizes the link between iodine and health, they can prevent the occurrence of iodine deficient health problems by providing people with iodine supplements, iodized oil, food fortified with iodine, and/or iodized salt. The last measure---using iodized salt---is the most common method for combating iodine deficiency because most cultures use salt. In fact, the World Health Organization (W.H.O.), and the United Nations Children's Fund (U.N.I.C.E.F.) are currently using iodized salt as their most common method for preventing iodine deficiency around the world.

Conclusion

Iodine is important to all humans, not only chemists working in the laboratory. The thyroid gland needs iodine to make thyroid hormones, which regulate proper body functioning. Not enough iodine intake in a person's diet leads to iodine deficiency disorders; too much iodine in the diet---although much less common in the world---can have unwanted toxic effects, ones that are somewhat similar to the effects caused by iodine deficiency. Goiter and cretinism are the two most common disorders relating to iodine deficiency. Unfortunately, soil composition and cultural interaction lead to iodine deficiency around the world. On the other hand, humans are fortunate in that they can take measures that will prevent the occurrence of iodine deficiency.

The most widely used preventive method is seen by looking in your cupboard and noticing the container of salt that is iodized to keep you healthy.

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