What do you mean by iodine deficiency?

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Much of the effort in eliminating IDD proceeds successfully without a sound understanding of its principal cause, a deficiency of iodine in the environment. There is a perceived need for a better understanding of iodine geochemistry so we can ensure that the small amount present in the environment can be used effectively. But what do we mean by iodine deficiency and how should we designate an area as being iodine deficient. From a medical perspective parameters such as urinary iodine or thyroid size can be used as a measure of iodine nutrition (Table 1).

Median Urinary Iodine Concentration (μg/l)	Corresponding Approximate Iodine Intake (μg/day)	Iodine Nutrition
<20	<30	Severe deficiency
20-49	30-74	Moderate deficiency
50-99	75-149	Mild deficiency
100-199	150-299	Optimal
200-299	300-449	More than adequate
>299	>449	Possible excess

Table 1: Scale used by WHO/ICCIDD/UNICEF to relate iodine nutrition to urinary iodine concentration. (after http://www.people.virginia.edu/%7Ejtd/iccidd/aboutidd.htm)

This refers to an iodine deficiency but is a reflection of the iodine status of the local population and not the environment. It is an anthropological fallacy[1] (the attribution of the characteristics of the population to the environment) to assume the presence of IDD can be used to define the low-iodine status of a region without levels of iodine being determined in that environment. Many mountainous and glaciated areas of the world have been labelled as iodine-deficient without any supporting evidence.

In the strictest sense of the definition an iodine-deficient environment must be one that is unable to supply a sufficient daily intake of iodine to the local population, with the assumption that the populace are totally dependent on the local environment for their diet and receive no supplementary iodine. We can measure the iodine levels in the crops, drinking water and atmosphere and the population, and make some estimates as to what these levels may be.

Environmental geochemists would define an environment's iodine status on the basis of measured iodine levels in materials such as soil, water or vegetation. It would be useful if we could use a single media to define a deficient environment. For iodine the question is, what is the best medium for defining iodine-deficiency?

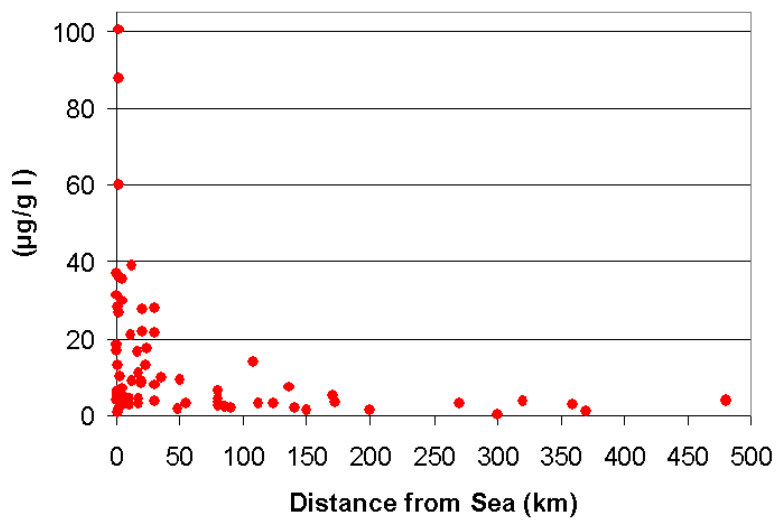

Figure showing the iodine content of soils plotted against the distance of the soil site from the sea (from Johnson, 2003)[3]

Our current project[2] looking at iodine in the environment has built up a database of over 2,200 soil analyses from all over the world[3]. Analysis of these data and information from the project's case study areas in China[4], Morocco[5] and Sri Lanka[6] suggest iodine in soils is a poor index of an environment's iodine status. The iodine status of a soil is a combination of the addition/removal of the element and the soil's ability to retain the iodine. The supply of iodine is usually high in coastal zones (0-50 km from the sea). This is shown in the plot of iodine in soils against distance from the seacoast. This figure is derived from the project's database of soil analyses using those results for which distance from the sea information was provided. There is no simple correlation between iodine in soil and the distance from the sea but there is a clear coastal zone of high but variable values. There will also be a greater input in regions of high-iodine rocks such as organic rich shales, although such rocks in terms of the overall global distribution are rare. The ability of the soil to retain iodine is a complex mixture of many parameters principal amongst which are the soil's organic content, the form of iodine in the soil and the prevailing Eh/pH conditions. Organic matter plays an important role in fixing iodine in the soil. Peats tend to be the most iodine-enriched of all soils. On a textural classification for soils the following order can be determined (mean value in µg/g I in brackets):

peat (7.0) > clay (4.3) > silt (3.0) > sand (2.2)

Contrary to what might first be anticipated, organic-rich soils, whilst enriched in iodine, are not good providers of iodine to the food chain because the iodine is strongly fixed and not bioavailable. Any consideration relating the iodine status of an environment to the iodine status of the population needs to look at the soil's bioavailable iodine and not the total iodine. Iodide seems to be the most mobile form of iodine in the soil and more readily taken up by plants. Acidic soil conditions favour this form of iodine whilst alkaline oxidising conditions (such as that found in dry thin soils of limestone areas) favour the less soluble iodate form. There is no need to invoke the presence of goitrogens in limestone areas which are noted for their high prevalence of IDD. Simple Eh/pH considerations would suggest the iodine in alkaline environments is less mobile.

A further failing in our use of iodine soil data is the fact that our sampling techniques only collect the solid part of a soil. By volume, a good loam soil will consist of 50% air and soil moisture and 50% of mineral and organic material. It is only in the latter portion that we determine for iodine. Iodine is considered as a mobile and volatile element and an indication of its bioavailability will surely depend on the presence of iodine in the pore spaces and soil moisture. The recent realisation that the geochemical cycle of iodine is dominated by volatilisation from the soil-plant interface to the atmosphere means we need to give far greater attention to the non-solid parts of the soil.

Unless the soil type is homogeneous across a significant area, soil iodine as a measure of environmental iodine status is very limited. The dependence of the soil iodine status on so many different parameters also makes inter area comparisons difficult. The use of vegetation as an index of environmental iodine levels is just as problematical not least because of the difficulty in determining the low levels of iodine present and the inconsistency in reporting results. Soil- to plant-iodine ratios are generally very low and variable (0.003 - 0.03) between plant species so it is difficult to use vegetation as a systematic parameter for iodine status, although plant contents give a good reflection of the bioavailable iodine.

Surface waters are probably the best index of the environment's iodine status. Their iodine represents the mobile form of the element and waters are more easily analysed than soils and vegetation. In areas studied by our project, where the population has been very dependent on the local environment for its diet, low levels of iodine in the surface drinking waters has been the best indicator of the environment's supply of iodine and generally correlates well with IDD prevalence. The Chinese Atlas of Endemic Diseases and their Environments[7] recognises that for most areas of IDD the prevalence rate is negatively correlated with drinking water. No threshold levels are stated but the maps suggest the greatest risks from IDD occur when levels are below 5 µg/l I. Early work in studying the prevalence of goitre in the UK[8] and USA[9] would suggest a threshold level of 3 µg/l I. As geochemists this is probably the closest we can get to providing a parameter for defining environmental iodine deficiency. However, it would be a mistake to base criteria for deficiency on the water levels alone.

If we return to the definition of environmental deficiency in its strictest sense, i.e. an environment that is unable to supply sufficient iodine for the local population, it is interesting to contemplate just how much of the land surface could be considered as "deficient". Based on drinking water of 5 - 10 µg/l I and intakes of 1 - 2 litres a day, 5 - 20 µg per day of our daily requirement can be accounted for. But what about the remaining 130 µg required to reach the Recommended Dietary Allowance (RDA)? Locally grown crops from all but the iodine-rich coastal zones of the world are unlikely to provide enough iodine. We have all become very dependent on the adventitious sources of iodine that come with development and industrialisation i.e. the " silent prophylaxis"[10], (e.g. iodophors in milk), the need for seafood or some form of iodine supplementation. In reality, most land areas of the earth are iodine-deficient and it is iodine sufficient areas that are the exception rather than the norm.

We now need to be careful not to imply the reverse of the anthropological fallacy - the environment is deficient so the population must be too. But this does invoke the question, in undeveloped areas of the world, where people continue to exist at a subsistence-level totally dependent on their local environment, why are IDD not more prevalent? Is this the difference between the RDA and an essential requirement for iodine? Our strict definition does require us to determine what a "sufficient" supply of iodine from the environment is.

The work on Environmental Controls in IDD has been sponsored by the UK Department for Internal Development (DFID) (see ICCIDD Newsletter November 1999). The project finishes in 2003, and all project reports and data will be available on the project's web site[2].

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