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Amelioration of the biogeochemical environment with iodine in kelp

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Abstract: An artificial way to prevent and cure the iodine deficiency disorder (IDD) through ameliorating the biogeochemical environment of the regions where iodine is deficient was put forward. In this paper, the concrete method to achieve this way was given and its feasibility is confirmed by test.

Key words: biogeochemical environment; iodine; kelp

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Introduction

Iodine is an essential trace element composing thyroxin that is of great importance for the growth of human body. It has been known that the deficiency of iodine is a major cause for an impediment of brain power. During the fetus and baby growing, if supplied a deficient iodine, they will be probably Kedin disease that the clinical manifestation is cretinism and deaf-mutism. About one billion people, including 425 million of Chinese people, live in the regions where iodine is deficient in the world. There are 10.17 million people who are deformities in brain power in China, in which above 80% were derived from deficiency of iodine. The deformities are increasing with a speed of one million per year, which has exerted directly an influence on total quality of Chinese people.

The iodine deficiency disorder (IDD) has received increasing attention in recent years. In 1991, the government of China promised to wipe out the IDD in China by the end of this century. At present, the government of China is adopting measure by iodating salt to prevent and cure the IDD in China. However, it is somewhat difficult to assess exactly the actual effect of this measure due to some problems concerning iodating salt. The physiological action of iodine on human health is subject to the Bertrand's law (Rong, 1992) which holds that the demand of human body for iodine is an extent of threshold. Both deficiency and excess of iodine concentration will bring about a high goiter. There are significant differences in demand of people in different age for iodine (Table 1; Lao, 1992). The degree of iodine deficiency in various regions is different. Even if in the same region, the degree of iodine deficiency of various people is different too. Therefore, it could be mistaking to supply iodine for all the people with iodated salt of the same iodine concentration. In addition, iodine in salt is difficult to be preserved because of its volatility. Iodine is so easy to lose during production, transportation and cooking that the effective concentration of iodine in salt is difficult to be controlled. In order to surmount these problems as mentioned above, this study is designed to ameliorate the biogeochemical environment by an artificial way in the regions where iodine is deficient. The artificial way is that the iodine enriched in kelp is directly transported by diatomite carrier to soil.

Iodine in human body comes from the food, drinking water and air, in which the food is 75%—80%, drinking water is 10%—20% and air is about 5%. In China, most of the regions where iodine is short supply are distributed in countryside. The iodine in human body is principally

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Table 1 Demand of iodine for various age groups

Age groups	Concentration range, μg/d	Just the right amount, μg/d
Under 4 years old	30—105	70
Above 4 years old and adult	75—225	150
Pregnant woman and wet nurse	150—300	200

supplemented by local food. On the basis of environmental geochemistry and biocycle of iodine, the terrestrial plants absorb iodine directly from water and soil, the thalassophyta absorb iodine directly from seawater and sediments, the animals obtain iodine from plants, water and air and the human body may obtain iodine from animals and plants as well as directly from water and air. In general, the people who live in inland regions obtain iodine only from the terrestrial food chain. The concentration of iodine in the terrestrial animals and plants is strictly controlled by the natural conditions of environment, in which the background concentration of iodine in soil is the most important controlling factor. Iodine in soil is transported easily by the rain water because the iodine is dissoluble. In the inland far from ocean, the amount of iodine leached by rain water is always more than that of iodine supplemented by rain water, although the rain water is one of major sources of iodine in soil. In some rainy regions where the terrain is declivitous and the soil is loose in particular, the iodine in soil is leached and transported violently. The serious deficiency in iodine of soil is inevitable outcome there, which brings about the deficiency of iodine in green plants and ultimately results in the iodine deficiency of a total food chain. To supplement iodine for soil may not only enhance directly the concentration for iodine in the food chain, but also improve gradually the background concentration of iodine around environment. It has been confirmed by the theory and test that the concentration of iodine in plant can be enhanced by applying the iod-fertilizer (Wang, 1985). The iod-fertilizer used for tests in the past, however, was too high production cost to be popularized. In our study, the iodine is directly transported from kelp to soil by the iod-compound fertilizer in which the diatomite acts as a carrier.

1 Materials and methods

1.1 Iodine in kelp

Kelp is a cryptogam. It is distributed widely in temperate seas. The kelp has the property of absorbing selectively some elements from seawater. Potassium and calcium in kelp are 100 and 50 times respectively than that in seawater. In particular, the dissoluble inorganic iodine in kelp is generally 0.2%—0.3% which is 10000—100000 times higher than that in seawater (average 0.06 ppm). Iodine in dry kelp is dissolved easily and becomes iodine ion in solution when it is leached. The iodine in the iod-compound fertilizer can migrate from kelp to soil when the kelp is broken down. The iodine ion dissolved in moisture of soil is easily absorbed by plants. In addition, potassium, calcium and organic matter enriched in kelp are the essential nutrient for plants.

The kelp used in this study was collected from the east sea of China where kelp is plentiful. In order to determine the activity of iodine in kelp, a leaching test has been done. The fresh dry kelp is smashed after clearing foreign substance. The powdery kelp is divided into five by equalization, and then are leached by water being 12 times higher than that powdery kelp. The leached times are from 1 to 5 hours, respectively.

1.2 Diatomite

The diatomite is composed of remains of diatom, clay minerals and terrigenous clastic in which the main clay minerals are montmorillonite, sericite and kaolinite. The major chemical composition of diatomite is amorphous SiO_2 that has special pore structure. Diatomite is selected as carrier of the iodine in kelp due to its larger surface area and good adsorption property. The content of organic matter and clay grains in soil that is seriously deficient in iodine is often low. Using diatomite as carrier in iod-compound fertilizer can not only enhance the contents of organic matter and clay grains in soil, but also adjust pH value of soil. These are of great advantage to fix iodine in soil so that iodine is not leached by soil water.

Diatomite used for this test was collected from Sheng County in Zhejiang Province, China where the diatomite resources is adapted to our study although it is limited to be used by industry because of its lower grade. The diatomite of Sheng County is determined for chemical composition and pore structure.

Two types of the iod-fertilizer are used by our study. One is the iod-compound fertilizer. The smashed diatomite adsorbing potassium from brine is added by given amount of nitrogen and phosphorus besides powdery kelp. This mixture is mixed fully and then is grained and dried under 60℃. Other one is the iod-fertilizer without diatomite.

1.3 Test of plant absorbing iodine

Eggplant, tomato and cucumber were chosen as the object of test for plant absorbing iodine. The seedlings of every plant were transplanted respectively in two pots in which one is contrast that is not applied the iod-fertilizer. Three plants were applied equal iod-compound fertilizer or iod-fertilizer without diatomite, respectively. After 30 days, the dissoluable iodine in soil was determined.

When the tested plants were ripe, they were collected from test and contrast pots respectively. The juices were squeezed from eggplant, tomato and cucumber for determining iodine.

2 Results and discussion

Fig.1 shows the change of iodine concentration in leached solution of kelp with leached time. The concentration of iodine in leached solution increases with leached time within 3 hours and decreases obviously with leached time after 3—4 hours. This is attributed to the significant difference in concentration of iodine between kelp and leached solution. In the beginning the iodine migrates from kelp to leached solution because of high iodine in kelp. With leached time increase, in general after 3—4 hours, the concentration difference between kelp and leached solution is diminished. The kelp can readsorb iodine from leached solution due to the higher adsorption capacity of kelp to iodine.

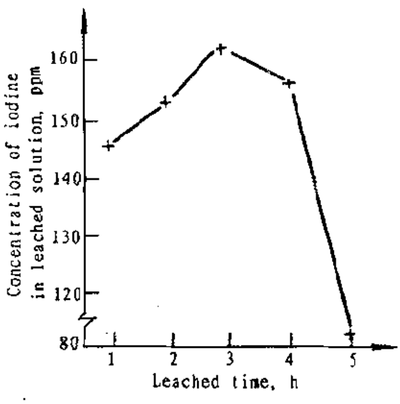

Fig.1 Relationship between concentration of iodine in leached solution and leached time

Table 2 and Fig.2 show respectively the chemical composition and pore structure of diatomite used in this study. As we see from Table 2, the diatomite collected from Sheng County contains higher clay component that needs to be purified if it is used in industry. However, this diatomite and its special pore structure favor iodine being kept in soil and released gradually for plants.

Table 2 Chemical composition of diatomite (%)

Components	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Burn away	Total
Content	64.21	0.91	14.19	2.79	0.25	0.03	0.65	0.63	0.78	2.06	0.06	13.67	100.23

Table 3 lists the concentration of dissoluable iodine in soil that was applied by the iod-fertilizer for 30 days. Samples No.1 and No.2 were collected from the soils that were applied by the iod-compound fertilizer with diatomite as carrier and by the iod-fertilizer without diatomite, respectively. Sample No.3 is contrast soil. The analytical results show that the concentration of dissoluable iodine in soil applied the iod-fertilizer is higher than that in contrast soil. This indicates that the status of iodine in soil has been obviously ameliorated. The variance in concentration of iodine in leached solution of soil applied the iod-fertilizer is in consonance with that in leached solution of kelp. After the soil was leached for 3 hours, however, the decrease of iodine concentration in leached solution of soil with leached time increase is directly in association with the adsorption of soil to iodine. It can be seen from Table 3 that the highest iodine concentration of leached solution in soil applied the iod-compound fertilizer with diatomite as carrier is significantly higher than that in soil applied the iod-fertilizer without diatomite. At leached times of 1 to 5 hours, the amounts of iodine leached from the soil that was applied by the iod-compound fertilizer are lower than that from the soil that was applied by the iod-fertilizer. These results explain that the diatomite in the iod-compound fertilizer plays a role in preserving iodine in soil.

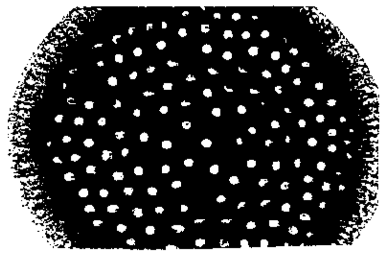

Fig.2 Pore structure of diatomite(a cross section, enlarged 1.6×10^4 times)

Table 3 Concentration of iodine in leached solution of soil(ppm)

Sample	Leached time, h		
	1	3	5
No.1	15.24	39.63	18.10
No.2	17.15	29.54	19.06
No.3	—	18.10	—

The ripe period of tested plants was shortened by about a week as compared with the contrast plants. It is suggested that this is in association with organic matter in the iod-fertilizer besides N, P and K.

Fig.3 shows the analytical results of iodine in juices of eggplant, tomato and cucumber. It is evident that the concentration of iodine in plants applied the iod-fertilizer is increased. This explains that the iodine in kelp has been transported to soil and is ultimately absorbed by the plants in the process of biogeochemistry. There is difference in absorption amount of various plants to iodine. If the accumulation degree (AD) of plant to iodine is defined by the ratio of the concentration of iodine in plant applied the iod-fertilizer to that in contrast plant, the AD can reflects directly the absorption capacity of plant to iodine. The AD of tomato, cucumber and eggplant are 4.7, 3.5 and 2.4, respectively. Although the absorption amount of eggplant to iodine is higher than that of tomato and cucumber, the absorption capacity ranks tomato > cucumber > eggplant. This result shows that the efficiency to enhance the concentration of iodine in plants through applying the iod-compound fertilizer is significant.

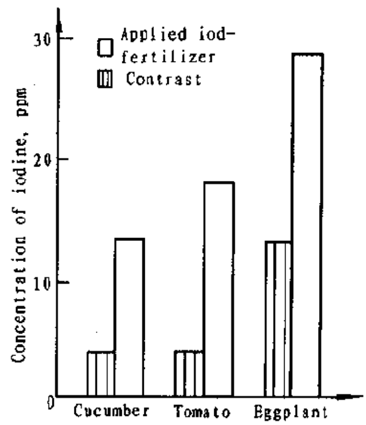

Fig.3 Concentration of iodine in plant applied the iod-compound fertilizer and contrast plant

3 Summary

It has been shown by test that iodine can be transported from kelp to soil through the iod-compound fertilizer, ultimately resulting in the increase in the concentration of iodine in plant by the biogeochemical migration and transformation of iodine. In this process, diatomite as a carrier of iodine in iod-compound fertilizer acts on controlling either transportation of iodine from kelp to soil or release of iodine from soil to solution in soil.

There is difference in absorption capacity of various plants to iodine in soil. The results show that the lower the original concentration of iodine in plants is, the higher the accumulation degree of the plants to iodine is. In the tested plants, the accumulation degree of iodine ranks tomato > cucumber > eggplant.

As compared with inorganic iodine in salt, the iodine in fruits or plants is not only easily absorbed by human body, but also can be better preserved. Therefore, the iodic green food has the functions of the health protection and prevention and cure of IDD. It can be estimated that a tremendous societal and economical efficiency will come into being with this iodic green food being exploited. It is of great significance that the background concentration of iodine in region will be enhanced besides the increase of concentration of iodine in food chain by applied the iod-compound fertilizer over a long period of time, which will gradually ameliorate the biogeochemical environment there.

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