Investigation on the Iodine Contents in the Soils in Japan.

By

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The senior author has reported previously on a quantitative method for determination of iodine[1] and also the results of investigation on the iodine content in the agar[2]. In this paper, the results obtained on the iodine contents in the soils in this country are presented, of which the information seems to be lacking so far as the authors are aware.

The soil samples, 112 in all which were sent in by the Agricultural Experiment Stations of 32 Prefectures, Formosa, Hokkaidô, Korea, Kuangtung and South Sea Islands, were analyzed and the results are considered in conjunction with the geological formation of each soil together with the soil nature, the soil condition and hydrogen ion concentration.

It has been known that even a very minute amount of iodine has a stimulating effect on the physiological activities of plants and animals while a large amount is harmful. Recently it was experimentally shown that the activities of Azotobacter chroococcum, B. subtilis and Saccharomyces cerevisiae[3] are influenced markedly by the presence of a certain amount of iodine. Again it was reported that the increase of crops, such as rice[4], peas[5], oats and radish[6], and sugar beets[7] was obtained by the application of iodine to the soil, and also the increase of the iodine contents in the crops was noted which is in parallel with that in the soils. Further it is a well known fact in the medical field that the iodine contents in the diet has a marked influence on the health of mankind.

The iodine is said to be distributed widely more or less in all parts of the earth, and its quantity increases as the depth of the litnosphere decreases. Lunde[16] found 100–150 r/Kg. (r = 1/1,000 mg.) in Eisenkern and 300 r/Kg. in Silkatmagma. In the surface layer, the iodine content varies by the geological formation, nature of soil, p_H, distance from the sea shore, manures and crops, and also by the management as reported by Remington[8] and others, and Reith[9].

It is naturally expected to find a considerable amount of iodine in the soils in this country, since the country is surrounded by the seas, and along the sea shores, the seaweeds are often used as a manure, and also the people are accustomed to use various kinds of seaweeds in their diet, whose excretes, in turn, have been applied to the soils frequently as a manure also.

For all these reasons, this investigation was undertaken to ascertain the iodine contents in the soils so that the results may be servisable.

Experimental:

The analysis was made by the closed combustion method[1] which has been reported previously, after the soil samples were air-dried and powdered, 1 mm. mesh size, and 20—25 g. were taken for a determination. The analytical results with the record of soils are given in Table I.

Table I.

Iodine Contents and the Record of Soils.

No.	Districts.	Geological system.	Soil nature.	Soil condition.	p_H	Iodine contents. (p.p.m.)
1.	Hokkaidô.	Alluvial.	Clayey loam.	Dry-farm.	6.28	1.206
2.	„	„	Loam.	Paddy-field.	6.04	56.531
3.	Akita.	Quaternary younger.	Clayey loam.	„	5.85	3.806
4.	„	„ „	„ „	Dry-farm.	5.97	1.268
5.	Miyagi.	„ „	„ „	Paddy-field.	6.04	2.048
6.	„	„ „	„ „	Dry-farm.	6.21	3.631
7.	Yamagata.	Diluvial.	—	„	5.93	35.007
8.	Fukusima.	Quaternary younger.	Sandy loam.	Paddy-field.	5.43	2.856
9.	„	„ „	Loam.	„	5.97	1.416
10.	„	Tertiary.	Clayey loam.	„	5.78	1.535
11.	„	Quaternary older.	Sandy loam.	„	5.76	1.011
12.	„	Quaternary younger.	Clayey loam.	„	5.47	0.729
13.	„	Tertiary.	Loam.	„	5.95	0.962
14.	„	Granite.	Sandy loam.	„	5.66	1.964
15.	„	Quaternary older.	Loam.	„	5.85	1.774
16.	„	Quaternary younger.	„	„	6.00	1.274
17.	Ibaragi.	Diluvial.	—	Dry-farm.	5.83	10.297
18.	„	Alluvial.	—	„	6.06	3.601
19.	„	Diluvial.	—	„	6.07	19.794
20.	Totiki.	Quaternary older.	Loam.	Paddy-field.	6.09	2.789
21.	Gunba.	Diluvial.	—	„	5.88	1.364
22.	„	„	—	Dry-farm.	6.18	4.454
23.	„	Alluvial.	—	Paddy-field.	5.85	2.147
24.	„	Volcanic.	—	„	6.06	2.008
25.	Tiba.	Quaternary younger.	Sand.	Dry-farm.	6.26	3.161
26.	„	„ „	Clayey loam.	Paddy-field.	6.97	4.026
27.	„	Quaternary older.	Loam.	Dry-farm.	6.58	2.788
28.	Tôkyô.	„ „	Clayey loam.	„	5.99	1.437
29.	„	„ „	„ „	„	6.09	17.021
30.	„	Quaternary younger.	„ „	Paddy-field.	6.23	1.384

Table I. (Continued.)

No.	Districts.	Geological system.	Soil nature.	Soil condition.	p_H	Iodine contents. (p.p.m.)
31.	Kanagawa.	Tertiary.	Loam.	Paddy-field.	6.32	7.196
32.	"	Quaternary younger.	Clayey loam.	Dry-farm.	6.67	7.119
33.	"	Quaternary older.	Sandy loam.	"	6.47	3.849
34.	Sizuoka.	Quaternary younger.	Loam.	Paddy-field.	6.15	2.455
35.	"	" "	"	Dry-farm.	6.75	0.806
36.	"	Tertiary.	Clayey loam.	"	6.04	1.129
37.	Gifu.	Alluvial.	Sandy loam.	Paddy-field.	6.38	1.659
38.	"	"	" "	Dry-farm.	6.73	2.186
39.	Isikawa.	"	" "	"	6.70	1.672
40.	"	"	" "	Paddy-field.	6.32	1.308
41.	Fukui.	Quaternary younger.	Clay.	"	6.11	2.380
42.	"	" "	"	"	7.51	1.843
43.	"	" "	"	Dry-farm.	6.06	6.202
44.	Mie.	" "	Loam.	Paddy-field.	6.07	0 625
45.	"	" "	Sandy loam.	Dry-farm.	6.70	0.753
46.	Nara.	" "	" "	Paddy-field.	6.21	0.578
47.	"	" "	Loam.	"	5.93	0.493
48.	Wakayama.	Alluvial.	"	"	5.80	2.583
49.	"	Diluvial.	"	"	5.73	1.873
50.	"	Alluvial.	"	"	5.71	1.467
51.	Ôsaka.	New diluvial.	Sandy loam.	"	5.92	0.638
52.	"	"	" "	"	6.18	5 038
53.	Tottori.	Diluvial.	—	"	7.51	37.935
54.	"	Quaternary younger.	Loam.	Dry-farm.	6.61	3 388
55.	"	" "	Sandy loam.	Paddy-field.	6.13	1.127
56.	Simane.	" "	Sand.	"	6.18	1.243
57.	Yamaguti.	Diluvial.	Clayey loam.	"	6.11	0.807
58.	"	"	" "	Dry-farm.	6.28	4.955
59.	"	Alluvial.	Sandy loam.	Paddy-field.	6.00	0.807
60.	Hirosima.	Quaternary younger.	Loam.	"	5.99	1.289
61.	"	" "	"	"	7.25	1.753
62.	"	" "	"	Dry-farm.	6.19	3.352
63.	Okayama.	" "	"	Paddy-field.	5.97	1 328
64.	"	" "	Sandy loam.	"	6.07	1.361
65.	"	Alluvial.	" "	"	6.13	1.431
66.	"	"	Loam.	Dry-farm.	5.27	0.980
67.	"	"	"	"	4.77	43.190
68.	"	"	"	"	5.61	7.881
69.	Kagawa.	"	"	Paddy-field.	6.73	0.883
70.	"	"	"	Dry-farm.	6.56	0.875
71.	Tokusima.	Archean.	"	"	5.87	2.656
72.	"	Quaternary younger.	Sandy loam.	"	5.76	5.259
73.	"	Mesozoic.	Clayey loam.	Paddy-field.	5.73	2.928

Table I. (Continued.)

No.	Districts.	Geological system.	Soil nature.	Soil condition.	P_H	Iodine contents.
						(p.p.m.)
74.	Ehime.	Diluvial.	Sandy loam.	Paddy-field.	6.21	1.410
75.	„	—	Volcanic.	Prairie.	5.88	30.810
76.	„	Diluvial.	Sandy loam.	Paddy-field.	5.88	1.036
77.	„	Granite.	Sand.	Dry-farm.	6.09	3.141
78.	„	Mesozoic.	Loam.	Paddy-field.	6.06	1.710
79.	„	Diluvial.	„	„	5.99	1.871
80.	„	Mesozoic.	„	Dry-farm.	6.26	7.640
81.	„	Alluvual.	„	„	6.21	10.569
82.	Kôti.	Archean.	—	Paddy-field.	6.04	3.549
83.	„	Diluvial.	—	„	6.13	2.664
84.	„	Mesozoic.	—	Dry-farm.	5.59	1.202
85.	„	Diluvial.	—	„	6.37	34.690
86.	Fukuoka.	Quaternary younger.	Loam.	Paddy-field.	6.52	1.462
87.	„	„ „	Sandy loam.	„	6.11	0.977
88.	„	„ „	„ „	Dry-farm.	7.05	2.394
89.	Saga.	Quaternary older.	Loam.	„	6.27	5.372
90.	„	Quaternary younger.	Clayey loam.	Paddy-field.	6.61	1.164
91.	Ôita.	„ „	Loam.	„	6.16	1.112
92.	„	„ „	„	Dry-farm.	6.16	1.058
93.	Miyazaki.	Diluvial.	Clayey loam.	„	5.74	26.560
94.	Okinawa.	Quaternary younger.	Loam.	„	6.77	9.703
95.	„	„ „	„	Paddy-field.	7.34	6.050
96.	Kuantung.	—	Sandy loam.	Dry-farm.	7.16	3.216
97.	„	—	Loam.	„	6.75	6.639
98.	„	—	„	Paddy-field.	6.94	4.800
99.	„	—	Sandy loam.	Dry-farm.	6.91	4.419
100.	„	Alluvial.	Loam.	„	7.16	4.169
101.	Korea.	„	„	Paddy-field.	6.28	1.246
102.	„	„	„	Dry-farm.	6.28	7.634
103.	Formosa.	Quaternary younger.	Sandy loam.	Paddy-field.	6.21	5.941
104.	„	Quaternary older.	„ „	Dry-farm.	6.09	18.500
105.	„	Quaternary younger.	Clayey loam.	Paddy-field.	7.21	0.756
106.	„	„ „	„ „	Dry-farm.	7.41	3.163
107.	„	Tertiary.	„ „	„	6.18	1.080
108.	South Sea Islands.	—	Red soil.	„	5.93	18.689
109.	„	—	—	—	6.77	23.567
110.	„	—	—	—	7.67	15.100
111.	„	—	—	—	6.05	50.780
112.	„	—	—	—	6.49	55 732

The foregoing results are arranged as follows by their original districts, and by the various amount of iodine found viz. < 1.0, 1.0—3.0, 3.0—5.0, 5.0—10.0, and > 10.0 p.p.m., and the average iodine content ; and shown in Table II.

Table II.

Distribution of Iodine in Different Districts.

Districts.	Iodine contents (p.p.m.)					Number of samples.	Average Iodine content.
	<1.0	1.0 – 3.0	3.0 – 5.0	5.0 – 10.0	>10.0		
							(p.p.m.)
Hokkaidô . . .		1			1	2	28.86
Akita		1	1			2	2.54
Miyagi		1	1			2	2.84
Yamagata . . .					1	1	35.00
Fukusima . . .	2	7				9	1.50
Totiki		1				1	2.79
Ibaragi			1		2	3	11.22
Gunba		3	1			4	2.55
Tôkyô		2			1	3	6.61
Tiba		1	2			3	3.32
Kanagawa . . .			1	2		3	6.05
Sizuoka	1	2				3	1.46
Isikawa		2				2	1.49
Fukui		2		1		3	3.48
Gifu		2				2	1.92
Mie	2					2	0.69
Nara	2					2	0.54
Wakayama . . .		3				3	1.97
Ôsaka	1			1		2	2.84
Tottori					1	1	37.93
Simane		2	1			3	1.50
Okayama . . .	1	3		1	1	6	9.28
Hirosima . . .		2		1		3	3.61
Yamaguti . . .	2		1			3	2.19
Kagawa	2					2	0.88
Tokusima . . .		2		1		3	3.36
Ehime		4	1	1	2	8	7.23
Kôti		2	1		1	4	2.72
Fukuoka	1	2				3	1.59
Saga		1		1		2	3.26
Ôita		2				2	1.09
Miyazaki					1	1	26.39
Okinawa				2		2	7.87
Korea		1		1		2	4.44
Kuantung . . .			4	1		5	4.65
Formosa	1	1	1	1	1	5	5.88
South Sea Islands.					5	5	32.77
Total. .	15	50	17	13	17	112	7.41

Table I and II indicate that the soil No. 2, from Hokkaidô Agricultural Experiment Station contained the maximum quantity of iodine, 56.53 p.p.m. ; No. 47, from Nara Prefecture was the minimum of 0.49 p.p.m., and the average for all the soils were 7.41 p.p.m. Among 112 soil samples, 15 of them contained less than 1 p.p.m. iodine ; 50 (1.0—3.0 p.p.m.) ; 17 (3.0—5.0 p.p.m.) ; 13 (5.0—10.0 p.p.m.) ; 17 (> 10.0 p.p.m.), and the percentage of these soil samples is as follows.

Table III.

Percentage of Soils relative to Iodine Contents.

Iodine contents. (p.p.m.)	<1.0	1.0 - 3.0	3.0 - 5.0	5.0 - 10.0	>10.0
Percentage of Soils.	13.3	44.6	15.1	11.6	15.1

A majority of soils contain 1.0—3.0 p.p.m. of iodine, but it is noteworthy that the percentage for > 10.0 p.p.m. was 15.1. Again between the quantity of iodine and the districts whence the soils came, a certain relationship was recognized. Among 37 districts, 11 of them were below 2 p p.m., and 12, over 5 p.p.m. On an average, the smallest was Nara Prefecture which was 0.54 p.p.m., and South Sea Islands was 32.77 which was the largest. The districts whence only one sample came was exempted.

The iodine contents in relation to various soil properties viz. geological system, soil classes, P_H, and soil condition, are reported below :

1.) Iodine contents and the geological system.

The iodine contents were examined in relative to the geological system to which the soils belong, and shown as follows :

Table IV.

The Relationship between the Iodine Contents and the Geological System.

Geological system.	Iodine contents (p.p.m.)					Number of soils.	Average Iodine
	<1.0	1.0 - 3.0	3.0 - 5.0	5.0 - 10.0	>10.0		(p.p.m.)
Quaternary younger.	8	30	8	5	3	54	4.76
Quaternary older.	2	10	3	2	6	23	9.34
Tertiary.	1	3	0	1	0	5	2.38
Mesozoic.	0	3	0	1	0	4	13.37
Palaeozoic.	0	0	0	0	1	1	18.50
Archean.	0	1	0	0	0	1	2.66
Granite Rock.	0	2	1	0	0	3	2.06

Table IV indicates that the older quaternary soils contain the largest amount of iodine followed by the younger of the same period. In general, the younger soils contained more iodine than the older ones.

2.) Iodine contents and the soil classes with special reference to the humus contents.

Table V gives the relationship between the soil classes and the iodine contents while Table VI shows that of the humus contents of the soils.

Table V.

The Relationship between the Iodine Contents and the Soil Classes.

Soil classes.	Iodine contents (p.p.m.)					Number of soils.	Average Iodine
	<1.0	1.0 - 3.0	3.0 - 5.0	5.0 - 10.0	>10.0		
							(p.p.m.)
Sand.	1	1	2	1	0	5	2.64
Sandy loam.	4	10	3	1	0	18	2.05
Loam.	4	17	3	3	2	29	4.48
Clayey loam.	2	10	4	2	2	20	7.42
Clay.	0	3	1	5	0	9	5.21

As shown above the clayey soils contained the largest amount of iodine which was followed by the loam, sand and sandy loam in the order.

Taking two or three soil samples from each group representing the iodine contents of <1.0, 1.0 and >3 p.p.m. of which the humus contents have been determined, and the relationship between the iodine and the humus contents was examined as follows :

Table VI.

The Relationship between the Iodine Contents and the Humus Contents in Soils examined.

No. of soil sample.	Soil classes.	Humus content in 1 g. dry soil.	Iodine content in dry soil.
		(g.)	(p.p.m.)
56	Sand.	0.0113	1.24
25	"	0.0100	3.16
51	"	0.0099	0.63
76	Sandy loam.	0.0197	1.03
33	" "	0.0195	3.84
59	" "	0.0135	0.81
11	" "	0.0111	1.01

Table VI. (Continued.)

No. of soil sample.	Soil classes.	Humus content in 1 g. dry soil.	Iodine content in dry soil.
			(p.p.m.)
46	Sandy loam.	0.0070	0.58
81	Loam.	0.0715	10.56
2	"	0.0185	56.53
48	"	0.0148	2.58
89	"	0.0145	5.37
44	"	0.0105	0.62
92	"	0.0099	1.05
47	"	0.0068	0.49
93	Clayey loam.	0.1052	25.56
19	" "	0.0408	19.79
4	" "	0 0231	1.26
57	" "	0.0088	0.80
39	" "	0.0062	1.67
30	Clay.	0.0335	7.04
102	"	0.0181	7.63
41	"	0.0093	2.38
42	"	0.0086	1.84

As Table VI indicates that in general it holds true that larger is the humus contents, the soils contained more iodine.

Considering these results, reported in Tables V and VI in the light of those from other countries, they show a similar tendency as a whole. FELLENBERG[10] reported that a large portion of iodine in the arable soil, is found in combination with the humus content or absorbed by the inorganic colloids ; BECK[11] states that 70% iodine in the clayey soil is found in combination with clay of less than 20 μ diameter ; KÖHLER[12] noted that the iodine content increases in the order of sandy soil, sandy loam, loam and clay.

3.) Iodine contents and hydrogen ion concentration of soils.

Considering the results obtained in conjunction with the concentration of hydrogen ions of soils, by grouping the soil samples into four groups, namely $>p_H$ 6.5, $<p_H$ 6.5, $>p_H$ 6.0 and $<p_H$ 6.0, the following relationship is noted :

(See Table VII on next page.)

As Table VII indicates, in the soils of $p_H>6.5$, about 1.7 times more of iodine was found on average than that in $p_H<6.5$ and also in $p_H>6.0$ more iodine was found than that in $p_H<6.0$, so that it may be stated that larger is the p_H, the soils contain more iodine.

Table VII.

The Relationship between the Iodine Contents and the pH of Soils.

p_H	Iodine contents (p.p.m.)					Number of soils.	Average Iodine.
	<1.0	1.0 - 3.0	3.0 - 5.0	5.0 - 10.0	>10.0		(p.p.m.)
>6.5	3	9	8	3	1	24	7.33
<6.5	9	43	10	8	9	79	4.35
>6.0	8	29	17	10	7	71	5.18
<6.0	4	23	1	1	3	32	4.74

In this regard, KÖHLER[12] noted the definite relation between the iodine content and the concentration of hydrogen ions viz. the neutral and alkaline soils contain more iodine ; FELLENBERG[10] reported that the amount of iodine evaporated from the soils increases with the increase of acidity of the soils ; REITH[9] investigated the soils in Holland and found that no loss of iodine by decomposition takes place in the soils of $p_H > 7.0$ while a big loss in the acid soils. The results obtained in our investigation agree with those reported in other countries.

4.) Iodine contents and the conditions of soils.

The soils from either the paddy-field or the dry-farm were grouped together and the average iodine content as well as the number of samples containing various amount of iodine were surveyed and are given in the following table :

Table VIII.

The Relationship between the Iodine Contents and the Soil Conditions.

Soil conditions.	Iodine contents (p.p.m.)					Number of soils.	Average Iodine.
	<1.0	1.0 - 3.0	3.0 - 5.0	5.0 - 10.0	>10.0		(p.p.m.)
Paddy-field.	11	38	6	4	3	62	3.99
Dry-farm.	3	14	12	7	7	43	8.27

As Table VIII indicates, the soils from the dry-farm contained iodine almost double the amount of those from the paddy-field. This may be due to the washing action in the paddy-field which is submerged in water and drained frequently.

Discussions :

Examining these results obtained in the light of those reported from other countries, the following comparison may be made :

BUNSEN and CARTE[13] investigated the Australian soils and reported that 9.6 p.p.m. as the maximum and 0.7 p p.m., the minimum and the average of 3.5 p.p.m.

In the soils in England and Scotland, ORR and REITH[14] reported that the iodine is present within the range of 0.6–6.0 p.p.m. KÖHLER[12] reported 2.0—2.5 p.p.m. as the average iodine content in Germen soils. McHARGUE[15] of the United States of America examined the soils from 62 different districts in that country and reported the maximum of 16.9 p.p.m., the minimum of 0.8 p.p.m. and the average of 4.59 p.p.m.

In our investigation, the maximum was 56.53 p.p.m. ; the minimum 0.49 p.p.m. and the average was 7.41 p.p.m.

Therefore it may be said that the soils in Japan contain much more iodine than those in other countries.

Summary.

One hundred and twelve soil samples in this country were examined for their iodine contents, and the results may be summarized as follows :

1.) A majority of soils contain 1—3 p.p.m., and 15.1% soils contain more than 10.0 p.p.m. The largest iodine content was 56.53 p.p.m., and the smallest, 0.49 p.p.m., and the average for all the soil examined was 7.41 p.p.m.

2.) The soils from the older quaternary period contained the largest amount of iodine followed by the younger in the same period.

3.) The clayey soils contained the largest amount of iodine which was followed by the loam, sand and sandy loam in the order.

4.) The soils of larger p_H contain more iodine on the average.

5.) The soils from the dry-farm contained iodine almost double the amount of those from the paddy-field.

Considering the foregoing results in comparison with those data which had been reported by the investigators in other countries, the soils in Japan, in general, contain much more iodine than those in other countries.

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