Investigation on the Iodine Contents in the Soils in Japan.

II. Influence of Natural Conditions and Manuring on the Iodine Contents.

By

Arao Itano and Yasuhiko Tsuji.

[June 20, 1935.]

In the previous paper[1], the relationship between the iodine contents and various nature of soils was reported while this paper deals with the influence of natural conditions and manuring on the iodine contents.

As to the natural conditions, the following five factors were considered :

1. Influence of seawater.
2. Soil on the hillside.
3. Soils from the surface and subsoil.
4. Kinds of fertilizers applied.
5. Water soluble iodine content.

The results are reported as follows :

1.) Influence of seawater on the iodine content of soil.

It has been well known that the seawater contains a fairly large amount of free iodine and the seashell, seaweeds and plankton contain more iodine than those which are growing on land. Consequently it was anticipated to find more iodine in the soils which are liable to subject to the influence of sea water than those otherwise.

Remington, Clup and Kolnitz[2] analysed for the iodine contents in the potatos grown in various localities and deducted that the influence of seawater is limited to a small area along the seashore. Kohler[3] reported that no influence of seawater is felt in a locality which is ten kilometers or so distance away from the seashore but the humus contents, P_H and other nature of soils play a marked influence. Again Gaus and Greissbach[4] noted that it is not always true that the soils along the seashore contain a large amount of iodine so that the influence of seawater disappears very rapidly. From these reports, it seem to be reasonable to suppose that the direct influence of seawater is limited to comparatively small area. However, so far as the authors are aware, no clear information is available as to the extent and distance which are influenced by the seawater :

Since this country is surrounded by the seas, it is interesting to know as to the extent of influence by seawater regarding the iodine contents in the soils. For this reason, this investigation was undertaken by taking the soils along the irrigation canal nearby here.

At the sametime the chlorine contents were determined, as it was done previously[5] and the results were considered in relation to the iodine contents.

Soil Samples:

The soil samples were collected along the Kurashiki irrigation canal which runs from the Takahashi river to Kojima Bay as shown in Fig. 1 and of which length is about sixteen kilometers.

One sample was taken from the arable and another from the virgin field nearby each other per one kilometer distance. The ▲ marks in Fig. 1 indicates the spots where the samples were taken. At the mouth of the river, the mud from the sea bed was taken which is designated by #1a, and also the sand of river basin #18 was taken. This locality is said to be the sea about 300 years ago and even now the lower portion of the Kurashiki river is flooded by the seawater at high tide.

Experimental:

The iodine was determined by the electric combustion method[6] after the samples were prepared as described previously[1].

The chlorine was determined by the electric method[5]. The results are given by the order per distance from the mouth of river, in Table I.

Table I.

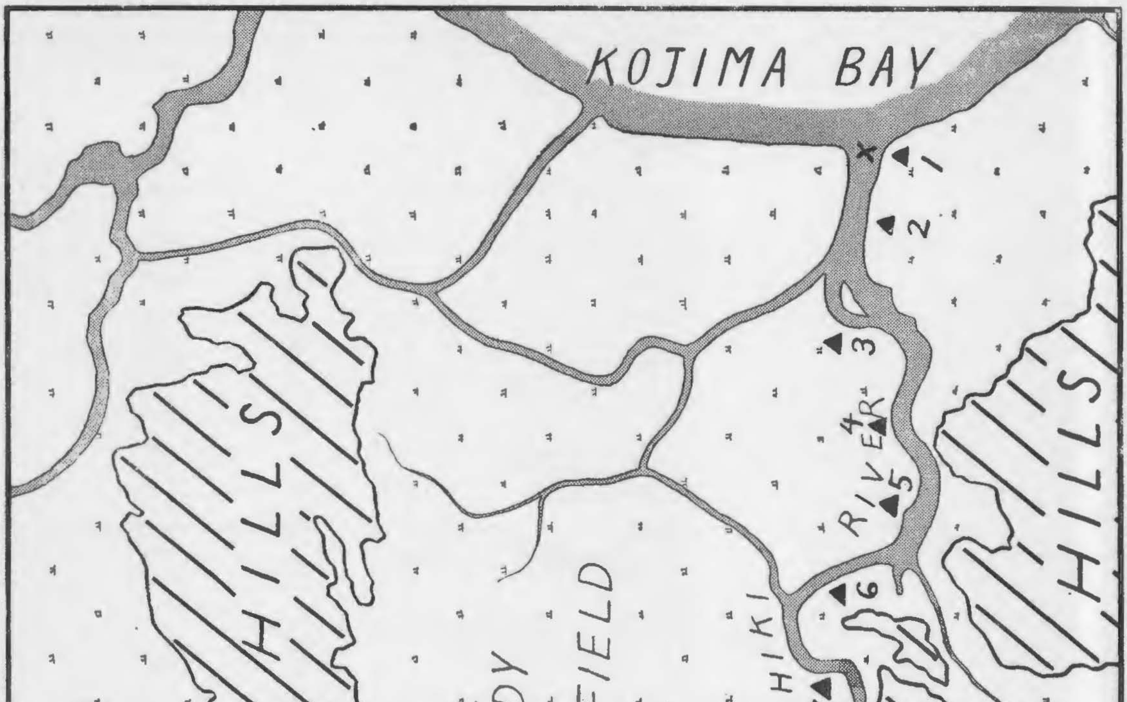
Soils along Irrigation Canal.

Soil No.	Distance from sea.	Virgin field 1 g. dry soil.	Arable field 1 g. dry soil.
	(km.)	(γ)	(γ)
1 a	0	23.126	—
1 b	0	15.169	8.983
2	1	16.720	3.345
3	2	6.775	4.810
4	3	5.647	8.509
5	4	6.688	6.775
6	5	5.267	5.501
7	6	3.972	2.527

(Continued to page 106 of the cover.)

Figure 1.

Places where the Samples were taken.



▲ = Indicates a spot where a sample was taken.

Table I. (Continued.)

Soil No.	Distance from sea.	Virgin field 1 g. dry soil.	Arable field 1 g. dry soil.
	(km.)	(γ)	(γ)
8	7	5.262	2.598
9	8	2.947	2.783
10	9	2.252	1.687
11	10	2.616	1.130
12	11	3.551	2.410
13	12	2.249	2.811
14	13	1.724	1.517
15	14	1.750	1.419
16	15	0.943	1.172
17	16	2.126	1.878
18	16	1.697	—
Average		5.039	3.521

Notes: $\gamma = \frac{1}{1,000}$ mg.; V# = Virgin soil samples; # = Arable.

As the above results indicate, V #1a contained almost twenty times as much as the soil from the upper stream, of which value agrees fairly well with that reported by BECK[7] who analysed the soil in the sea bed and found 0.534 mg. Iodine per 20 g. soil; V #1b was taken from the inside of bank where the reed is growing and flooded at the high tide, of which the iodine content decreases already comparing with that of V #1a, V #2 and V #1b are almost alike but a marked decrease was noted with V #3 and to #8 decreases slightly but from V #9 on shows a rapid decrease to almost ½ and remains almost constant up to V #17.

Although V #18 came from the Takahashi river basin where constantly washed by the fresh water, contained comparatively a large amount of iodine. As a whole, the iodine contents in the soils decrease gradually by the distance from the mouth of river, in case of the virgin soils. A majority of arable field was the paddy-field and the samples were taken when the field was not flooded. A marked variation in the iodine contents among the soils from the adjacent field was found. Sample #1b contained the largest quantity of iodine and with an exception of #3, a regular decrease was found up to #6 while in #7 the decrease was very marked.

Although after #7 up to #17 no marked change was noted. From these results, it may be said that the influence of seawater in the arable field ceases at six kilometers.

The iodine content of arable soils are less than those found in the virgin soils, the maximum of the former is about one half of that of the latter. This difference may be due to the washing by the irrigation in case of the arable soils while the virgin soils are influenced by the seawater farther inland.

The chlorine contents were determined at the sametime since the nature of both are similar in the seawater and existing in large quantity.

The results are given in Table II together with p_H and chlorine contents.

Table II.

Comparison among Iodine Chlorine, Contents and pH.

Soil No.	Distance from sea.	Virgin field.		p_H.	Arable field.		p_H.
		Iodine.	Chlorine.		Iodine.	Chlorine.	
	(km.)	(γ)	(mg.)		(γ)	(mg.)	
1 a	0	23.126	12.272	8.1	—	—	—
1 b	0	15.169	3.710	6.0	8.983	1.008	6.1
2	1	16.720	0.702	7.7	3.345	0.460	5.7
3	2	6.775	2.297	7.4	4.810	0.306	5.5
4	3	5.647	0.741	6.4	8.509	0.429	4.8
5	4	6.688	0.762	5.0	6.775	0.427	4.5
6	5	5.267	1.001	7.3	5.501	0.557	4.9
7	6	3.972	0.661	5.4	2.527	0.824	5.0
8	7	5.262	0.328	7.1	2.598	0.143	5.7
9	8	2.947	0.045	4.5	2.783	0.013	5.0
10	9	2.252	0.055	6.4	1.687	0.030	4.8
11	10	2.616	0.035	6.2	1.130	0.040	4.9
12	11	3.551	0.040	7.4	2.410	0.040	5.3
13	12	2.249	0.020	7.1	2.811	0.106	5.1
14	13	1.724	0.030	6.1	1.517	0.030	4.8
15	14	1.750	0.015	7.4	1.419	0.045	5.2
16	15	0.943	0.055	5.8	1.172	0.060	5.3
17	16	2.126	0.010	7.2	1.878	0.060	5.0
18	16	1.697	0.005	8.0	—	—	—

As Table II indicates, the chlorine contents were high near the mouth of river in both arable and virgin soils, and the decrease was slight up to #8 while the sudden decrease was noted by #9 which contained about 1/10 of that of #8. In general the arable soils contained less chlorine than the virgin soils. No parallel relationship was found between the chlorine and iodine contents of the soils, but in both cases the influence of seawater disappears at about eight kilometers from the mouth of river.

The hydrogen ion concentration of virgin soils was lower than that of the arable soils as it was found in case of the iodine contents although no interrelationship was found among individual value of P_H and iodine.

2.) Iodine contents of the soils on hillside.

It was anticipated that the iodine contents in the soils at the foot and top of hill may be different on account of the weathering and other factors which influence them differently.

Samples #19 and #20 were collected from the two hills Kurashiki near respectively. One hill was about hundred meters high and the other, about sixty-two meters, and both hills are covered with pine trees and shrubs halfway up the hills. The samples were taken from different spots on the hillside as noted in the table, and in case of #19 the humus content and P_H were determined.

Table III.

Iodine Contents in Soils from Hill.

Soil No.	Location.	Iodine contents.	Humus contents.	P_H.
		(γ)	(mg.)	
19	Farm at the foot of hill.	2.103	16.683	5.08
"	Foot of hill.	2.141	8.886	4.53
"	Halfway up.	2.261	9.424	4.79
"	Top.	1.820	6.024	4.55
20	Farm at the foot of hill.	4.118	—	—
"	Foot of hill.	3.944	—	—
"	Halfway up.	5.235	—	—
"	Top.	4.114	—	—

As shown in Table III, no marked variations among the iodine contents of these samples was found, indicating that on the hillside as high as these hills investigated, the iodine contents in the soils at different height are similar although between the hills themselves, the quantity of iodine is different.

3.) Iodine contents in the soils from the surface and subsoil.

In general, it is anticipated to find more iodine in the surface soil than in the subsoil owing to the fact that they differ in respect to the inorganic and organic constituents.

Since, as it was reported previously, the iodine content is related to the humus and clay content and also pH, it is naturally expected to find a relative difference among the soils of different depth. In regard to this question, KOHLER[8)] reported that under the normal condition, more iodine is found in the surface soils than in the subsoils, and the amount of iodine decreases per depth of the soil. BECK and SCHLACHT[8)] investigated the soils under different climatic belt, and found that in case of the prairie soil, the iodine content was highest in the surface and A, —A stratum, in brown forest and podsolized soils, the B stratum was the highest.

The soils from Kyoto and in this prefecture were analysed for the iodine content and the results are reported in Table IV.

Table IV.

Iodine Contents and Different Depth of Soils.

Soil No.	Localities.	Conditions.	Depth.	Iodine contents.
				(γ)
1.	Okayama-ken, (Jyodo-gun).	—	a. Surface (3 cm.).	0.955
			b. Subsoil (30 cm.).	2.060
2.	Ibid , (Oda-gun).	Virgin soil.	a. Surface.	1.284
			b. Subsoil.	0.880
3.	Ibid , (Oku-gun).	—	a. Surface.	4.669
			b. Subsoil.	3.151
4.	Tottori-ken, (Daisen-hara).	Virgin soil.	a. Surface.	63.401
			b. Subsoil.	60.614
5.	Kyoto, (Uji).	Dry-farm.	a. Surface.	6.658
			b. Subsoil.	9.385
6.	Ibid , (Kita-shirakawa).	"	a. Surface.	3.229
			b. Subsoil.	2.957
7.	Ibid , (Kuse-gun).	"	a. Surface.	6.337
			b. Subsoil.	5.371

As Table IV indicates, the iodine content was larger in the surface than in the subsoils. Further investigation was undertaken with soils from the paddy-field at this institute since the soils were examined previously were virgin and those form the dry-farm, and the results are noted in Table V.

Table V.

Iodine Contents and Different Depth of Soils, Humus Contents and pH.

Soil No.	Conditions.	Depth.	Iodine contents.	Humus contents.	p_H.
			(γ)	(mg.)	
1.	Dry-farm.	a. Surface soil.	3.886	8.689	5.49
		b. Subsoil.	2.924	5.145	6.44
2.	Ibid.	a. Surface soil.	2.724	12.017	6.89
		b. Subsoil.	1.582	11.209	6.98
3.	Ibid.	a. Surface soil.	2.190	8.872	4.60
		b. Subsoil.	1.297	6.550	6.17
4.	Paddy-field.	a. Surface soil.	1.247	13.098	5.51
		b. Subsoil.	1.963	3.223	7.85
5.	Ibid.	a. Surface soil.	1.385	7.266	6.06
		b. Subsoil.	2.031	2.720	7.63
6.	Ibid.	a. Surface soil.	0.833	10.804	5.09
		b. Subsoil.	2.191	4.034	7.12

Table V indicates that in case of the dry-farm more iodine was found in the surface soils than in the subsoil while with the paddy-field, the reverse was true. Examining these results in conjunction with the humus contents and p_H values of these soils, both of which were higher in the surface soils than in the subsoils, and it was naturally expected to find more iodine in the former than in the latter. Again as to the nature of the profile in the same experimental plot where the soil samples were taken, ITANO and ARAKAWA[9] reported as follows:

Field condition.	Depth in cm.		
Paddy-field.	19	Alluvial.	Sandy loam.
	43		Gravel.
Dry-farm.	24	Alluvial.	Loam.
	49		Sandy.

In both of the field conditions, less clay was found in the subsoils. Judging from these factors noted above, it is naturally expected to find more iodine in the surface soils than in the subsoil in all the soils investigated here. However, in case of the paddy-field, the results obtained were contrary to the expectation, which may be due to the action of irrigation water, carrying down the iodine to the subsoil. It is noted in general that iodine contents in dry-farm soils are much higher than that in the paddy-field.

4.) Kinds of fertilizers applied and iodine contents in the soils.

As to the necessity of application of iodine as fertilizer, it remains to be questionable, but it was experimentally proven that various kinds of fertilizers contain a considerable amount of iodine as shown by FELLENBERG[10], as follows :

Fertilizers.	Iodine contents. (γ per 1 kg.)	Fertilizers.	Iodine contents. (γ per 1 kg.)
Chili-saltpeter. · · · · ·	49.000	Ammomins sulfate. · ·	280.0
Calcium superphosphate.	5.700	Calcium cyamide. · · ·	40.0
Kinit. · · · · · · · · ·	440.0	Barn manure. · · · ·	400.0
Potassium sulfate. · · ·	25.0		

As noted above, both Chilo-saltpeter and calcium superphosphate contain a large quantity of iodine so that, by applying them to the soil, a certain amount of iodine is introduced to the soil. Regarding this question, REMINGTON, CLUP and KOLNITZ[2] analysed potatos in different soils of known iodine contents and using Chili-saltpeter as manure, and found the parallelism between the iodine content of potatos and that of the soils but no direct influence of Chili-saltpeter. Again GAUER[12] reported that the increase of iodine in the surface soil is brought about by the crop and barn manure and is not effected as to their content and concluded that the quantity of iodine added to the soil by the chemical fertilizers is very small compared with that already existed in the soil. Consequently it is not true that the continuous use of chemical fertilizers causes the exhaustion of iodine in the soil.

Table VI.

Iodine Contents and Fertilizers used.

Manuring.	Iodine contents.
	(γ)
No fertilizer (Field).	0.942
N. P. K. · · · · · · ·	1.571
N. P. K. Compost. ·	1.938
No fertilizer (Pot). ·	1.085
Bean cake. · · · ·	1.362
Compost. · · · · ·	1.801
Dry blood. · · · · ·	1.727
Fish meal. · · · · ·	2.395
Chilian saltpeter. ·	1.175

From the foregoing reports it may be said that the influence of chemical fertilizers on the iodine contents of soil is not direct but rather indirectly increase the organic content of soil so that the absorption capacity for iodine of the soil is increased. Further it was investigated to ascertain if iodine supplied to the soil with inorganic fertilizer would be lost or retained in the soil influenced by the compost and other soil organic manure. For this purpose, the soils from different source which were under different fertilizer treatment as noted in Table VI, were examined and obtained the results presented below :

Table VI indicates that the application of fertilizers increased the amount of iodine in the soil regardless of organic or inorganic although the increase was greater where the organic fertilizers were added. Among the organic fertilizers, the animal fertilizers were better than those of plant in this respect.

5.) Determination of water soluble iodine in the soils.

It is a matter of great interest to know as to the quantity of water soluble iodine especially in the paddy-field which is flooded sometime during a year or saturated with it for the rest.

Regarding this question, FELLENBERG[14] reported that only the inorganic from of iodine in the soil is water soluble and noted that 0.013 mg. out of 1.157 mg. iodine in 1 kg. soil was dissolved in water.

McHARGUE and others[15] reported that the lime substratum of Kentucky soil contains 130 p.p.b. of water soluble iodine. Again BECK[7] noted that 5% total iodine in the garden soil and 23% that in the soil on seashore, were dissolved out by percolation.

Judging from these results cited above, the water soluble iodine in the soil is comparatively small in quantity. However, its quantity seems to be influenced by various factors. Consequently twelve soil samples which were used in our previous investigation were taken and subjected to the following tests: 50 g. air-dried soil, shifted thru 1 mm. sieve, were mixed with 500 cc. water and left standing for 5 hours with an occasional shaking; filtered and 400 cc. filtrate were made alkaline with an addition of $CaCO_3$ and evaporated down to solid, and the iodine was determined by the closed combustion method. The results are reported in Table VII.

Table VII.

Water-soluble Iodine in Soils.

Soil No.	Total iodine.	Water-soluble.	Water-soluble I / Total I	Humus.	p_H.	Condition.	Soil class.
	(γ)	(γ)	(%)	(mg.)			
52	5.038	0.162	3.2	—	6.2	P	Sand.
56	1.243	0.203	16.4	11.3	6.2	P	„
8	2.856	0.257	8.8	—	5.4	P	Sandy loam.
33	3.849	0.417	10.8	19.5	6.5	D	ibid.
88	2.394	0.234	9.8	—	7.1	D	ibid.
27	2.788	0.286	10.3	—	6.6	D	Loam.
4	1.268	0.056	4.4	23.1	6.0	D	Clayey loam.
40	1.308	0.171	13.1	—	6.3	P	ibid.
31	7.196	0.348	4.8	—	6.3	P	Loam.
42	1.843	0.275	14.9	8.6	7.5	P	ibid.
49	1.873	0.122	6.5	—	5.7	P	ibid.

Table VII. (Continued.)

Soil No.	Total iodine.	Water-soluble.	Water-soluble I / Tatal I	Humus.	P_H.	Condition.	Soil class.
	(γ)	(γ)	(%)	(mg.)			
102	7.634	0.121	1.6	18.1	6.3	D	Loam.
* 1a	23.126	0.588	2.6	—	8.1	V	—
* 1b	15.169	0.250	1.6	—	6.0	V	—
* 1b′	8.983	0.177	2.0	—	6.1	V	—
* 5	6.688	0.356	5.3	—	5.0	V	—

Notes: P = Paddy-field; D = Dry-farm, V = Virgin.
* = Indicate the place where the samples taken per Fig. 1.

Table VII indicates that the percentage of water soluble iodine varies from 1.6% to 16.4% which vary by the soil, and no definite relationship was found in regard to the nature of soil or the total iodine content.

Although GAUS and GRIESSBACH[4] reported that iodine in the seashore soils is washed away easily, it was not marked with the soil samples #1a, #1b and #1b′ which came from the seashore.

Summary.

The iodine contents of soils were investigated in regard to five different factors and the results obtained may be summarized as follows:

1.) The sea-water influence the iodine content in soils, and the soils near the seashore contain twenty times as much iodine as the soil from the upper stream in case of the virgin field. But in the arable soils, the difference was not so marked.
2.) The influence of sea-water on the iodine contents of virgin soil ceases at six kilometers or so from the mouth of the irrigation canal while in case of the arable soil the influence ceases quicker.
3.) No definite relation between chlorine and iodine contents was found but the influence of sea-water was similar in both cases.
4.) The iodine contents of the soils on the hillside were about the same up to 100 meters.
5.) As to the iodine contents in the soil from the surface and subsoil, more iodine was found in the surface soil in case of the dry-farm and virgin field while in the paddy-field it was opposite.
6.) Application of inorganic fertilizers increases the iodine contents and more so where the organic fertilizers are added. Among the organic fertilizers, those from the animal source were more effective than the plant source.
7.) The percentage of water soluble iodine in the soils varies form 1.6 to 16.4 but no definite relationship was found in regard to the nature of soils.

Literature.

1.) ITANO, A. and TSUJI, Y., J. Sci. Soil and Manure, Japan, 8 : 4—7, 1934.
2.) REMINGTON, R. E., CLUP, F. B., and KOLNITZ, H. V., J. Amer. Chem. Soc., 51 : 2942, 1929.
3.) KOHLER, R., Z. f. Angew. Chem., 42, 1929.
4.) GAUS, W. u. GRIESSBACH, R., Z. Pflanzenernahr. Düng. u. Bodenkunde, T. A. 13 : 321, 1929.
5.) ITANO, A. and MATSUURA, A., Berichte Ōhara Inst. etc., V : 171, 1931.
6.) ITANO, A., Ibid. VI : 54, 1933.
7.) BECK, J., Z. Pflanzenernahr. Düng. u. Bodenkunde, T. A. 16 : 57, 1930.
8.) BECK, J. u. SCHLACHT, K., Ibid. T. A. 18 : 274, 1930.
9.) ITANO, A. and ARAKAWA, S., J. Agr. Chem., Japan, V : 166, 1929.
10.) FELLENBERG von T., Biochem. Z., 152 : 116, 1924, 160 : 210, 1925.
11.) SCHARRER u. SCHWAIBOLD, Ibid. 195 : 233, 1928.
12.) GAUR, G., J. f. Landw., 77 : 251, 1929.
13.) REITH, J. F., Z. Pflanzenernahr. Düng. u. Bodenkunde, T. A. 31 : 215, 1933.
14.) FELLENBERG von T., Biochem. Z., 188 : 326, 1927.
15.) MCHARGUE, J. S., ROY, W. R. and PELPHREY, J. C., Amer. Fert., 73 : 10, 1930.