Chemical Investigation on the Water of Rivers in Japan.

I. On the Quality of Water in Akita Prefecture.

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Contents

I. Introduction.

Whereas in our country the cultivation of rice is the main feature of agriculture, it is necessary to irrigate with a great deal of water for its cultivations.

River, lake, marsh, subterranean water etc. are sources of irrigation, and of course none of these are ever pure H_2O from the chemical view point. They contain various chemical constituents besides gases. This is attributable to the fact that rainfall which originates from aqueous vapour in the atmosphere first permeâtes underground, then flows out to the surface of the earth in the form of springs, and eventually pours into the sea or ponds as rivers. Through these natural courses, though on a small scale, water erodes and dissolves the substances in surrounding rocks or soil.

It can be said that the main factors which constitute chemical features in respect of quality of such water are the kinds of rocks, stones or soil in the gathering area, and also climate, configuration, hot springs, living things, cities, towns, mines etc. with complicating influeneces. The author intended to clarify these influences and at the same time to investigate the quantity of fertilizing substances naturally supplied to paddy fields through irrigation.

For this purpose he has continued to make systematic chemical investigations on the quality of water in the main rivers of Japan.

Judging from the results obtaind so far, the quantities of fertilizing substances naturally supplied to paddy fields through irrigation are never small. For instance, the amount of potash supplied to each acre of paddy fields during the irrigation period in a summer, shows a maximum of 40 kg and a minimum of 4 kg, and 6.5—7.5 kg as the medial. On this estimate entire 7,500,000 acres of paddy fields in Japan, a corresponding 120,000 tons of sulfate of potash are supplied; for nitrogen compounds 40,000—50,000 tons of sulfate of ammonia; and for calcium carbonate and silica it is presumed that about 1,000,000 tons of each respectively.

Thus it will be perceived that through irrigation unexpectedly enormous quantities of potash, lime and silica are supplied as natural fertilizer.

However, as mentioned above, the quantity of fertilizing substances contained in river water varies according to the nature of the soil or other conditions in the gathering area.

Investigation of these points to reveal how important a role irrigation water plays in producing rice crops, is one of the momentous missions assigned to us the agricultural technicians who have to increase the product of staple food stuffs under such a stringent situation when there is such a shortage of fertilizers as in the present day in Japan.

He has now to report herewith the results of chemical investigation on the quality of water, a task covering 12 months, beginning in April in 1942, and carried out on the twenty six main rivers beginning with the Yoneshiro and the Omono which were chosen to inspect the general tendencies of the quality of irrigation water in the area of Akita prefecture.

II. State of Irrigation.

In order to observe the utilization of irrigation in general in the Akita prefecture, the irrigated area of each river and of its tributaries are mentioned separately.(1)

The whole area of paddy fields irrigated from the river Omono and its water system is 142,082 acres; those of the Yoneshiro and the Koyoshi are respectively 52,774 acres; and 27,412 acres, and for others 57,621 acres. They aggregate 279,889 acres.

The river Yoneshiro and its water system

	Outlets	Irrigated area
Led from river	885	42,500 acres
Led from reservoir	414	5,539
Led from lake or marsh	50	1,490
Led from subterranean water	134	966
Led from other sources	70	2,279
Total	1,553	52,774

The river Omono and its water system

Led from river	919	94,132 acres
Led from reservoir	672	28,558
Led from lake or marsh	52	3,595
Led from subterranean water	471	11,248
Led from other sources	128	4,549
Total	2,242	142,082

The river Koyoshi and its water system

Led from river	400	17,368 acres
Led from reservoir	449	7,830
Led from lake and marsh	3	27
Led from well	23	74
Led from spring	134	336
Led from other sources	63	1,777
Total	1,072	27,412

Other waterways

Led from river	225	22,877 acres
Led from reservoir	816	22,645
Led from lake or marsh	160	6,056
Led from well	865	649
Led from spring	434	2,446
Other sources	89	2,948
Total	2,589	57,621
Grand total	7,456	279,889 acres

III. General remarks on river condition.

The general situations of the main rivers Yoneshiro, Omono, and Koyoshi in Akita prefecture are as follows.

1. *The river Yoneshiro and its water system.*

This river and its tributaries pass through the northern part of Akita prefecture from east to west; its basin borders on Aomori prefecture in the north it is bounded by the Tomaridake mountain range; in the east, it is separated from the upper part of the rivers Mabuchi and Kitakami by the Shikaku and Takakura mountains, a part of the central spinal range; in the south it is separated from the river Omono by the mountain chain of Yake, Moriyoshi and Shirako.

The main stream of the river Yoneshiro originates from the mountain chain of Shikaku (1,003 metres) and Takakura (1,051), taking a westward course, and it enters the bounds of Akita prefecture, turns to the north west and joins the river Oyu, which flows down from the south of lake Towada, on the right side in the neighbourhood of the town Kemanai. Thus increasing its water volume all at once it turns to the west and passes through a mountain range, joining the river Nagaki and other tributaries at a plain near Odate. Then it combines with the river Ani, the big tributary, on the left and also the river Fujikoto on the right at Takanosu plain.

The main stream flows through narrow places zigzagging. Through Noshiro plain it pours in the end into the Japan Sea. The length of the main stream is 83 miles and its basin extends to 1,578 sq. miles.

There are many thick forests in the mountainous part of this area with luxuriant foliage of broad- and needle-leafed old trees.

While the water volume of the river decreases in January and February, it increases gradually from the last part of March due to snow thawing, and reaches to a maximum in April and then diminishes slowly to its minimum point in July.

The water volume fluctuates often from August to November because of rainfall.

There are many good cultivated paddy fields along the river, and at the time of irrigation much water is utilized from the main and tributary rivers.

There are many places in the area where its geological nature shows volcanic and tuffs of tertiary period stratum, while the flat regions extending to Hanawa, Kemanai, Odate, Takanosu and Noshiro are those of quarternary period stratum.

Here are found many famous mines such as Kosaka, Osaruzawa and Hanaoka and the polluted water therefrom has much effect upon the water quality of the river Yoneshiro.

2. *The river Omono and its water system.*

This is the biggest river in Akita prefecture, the basin of which is separated in the east, by the central spinal mountain range, from rivers which form the western part of the river Kitakami; in the south, from the river Mogami by the mountain range which runs westward from Mount Kurikoma.

It takes its rise in the southern end of Akita prefecture, and after joining the rivers Yakunai, Takamatsu and Minase on the right, passes through Okatsu plain to the north and then joins the rivers Asahi and Tama, the biggest tributary, on the right.

Changing its course to the west it winds through mountain ranges and combines with the rivers Yodo and Iwami on the right and then pours into the Japan Sea, with Akita city to the east. It is 88 miles in its length, and the area of its basin is 1,804 sq. miles, comprising 4 districts of Okatsu, Hiraka, Senboku, Kawabe and a part of the Minamiakita district.

Along the upper part of the river opens the Okatsu flat, Senboku flat in the middle and Akita flat at the lower part.

Geologically the flat region along the main stream extending from the neighbourhood of Yokobori town down stream; also the plain along down stream and along the tributary rivers Minase and Tama are of quarternary period stratum respectively.

Volcanic rocks extends in the north to the mountainous region north of lake Tazawa along the river Tama, and in the south to the prefectural boundary, that is to the mountainous regions of the upper parts of the rivers Omono, Yakunai, Takamatsu and Minase.

Besides the above, exposures of volcanic rock can be observed here and there.

Except in these parts, most of mountainous and hilly regions consist of tuff and shale of the tertiary period stratum.

But granite exposures are to be seen at the upper part of the river Iwami.

The condition of the forests in this basin is generally good, especially the upper part along the tributary river Tama which is covered with unbroken thick forest, so that even in the dry season water is comparatively abundant. As to prcipitation volume, it is little in the central flat region such as Omagari and Yokote, while there is much more in the mountainous part. However, generally speaking, water is most abundant in July and August in summer, and in January and Feburuary in winter. Days of precipitation are numerous in the snowfall of winter. The current is low from January to March, but it increases slowly from April because of snow thawing and it reaches its maximum at the biggining of May. Then it decreases gradually to the last part of June when the dearth of water in summer begins.

In autumn many floods are experienced due to rainfall.

Well cultivated fields develop along both main and tributary streams and much irrigation water is utilized in summer.

There are many springs of sulfuric nature in the areas of the tributary rivers Tama and Takamatsu, and river water shows acid reaction.

3. *The river Koyoshi and its water system.*

This river passes through the center of Yuri district, in the sourhwestern part of Akita prefecture.

The upper stream is called the river Sasago and on the left side joins the river Chokai, which originates from Mount Chokai in the south. It is then called the river Koyoshi and turns to the northwest passing the northern end of Honjo town pouring into the Japan Sea.

The area of this basin is 453 sq. miles and occupies a major part of Yuri district.

Geologically volcanic rock is in abundance and the tertiary period stratum ranks next; the quarternary period stratum is observed in the flat region down stream.

VI. Places at which sample water was taken for investigation.

Out of the main rivers heading the Yoneshiro and Omono, the undermentioned twenty-six places of investigation in all were chosen.

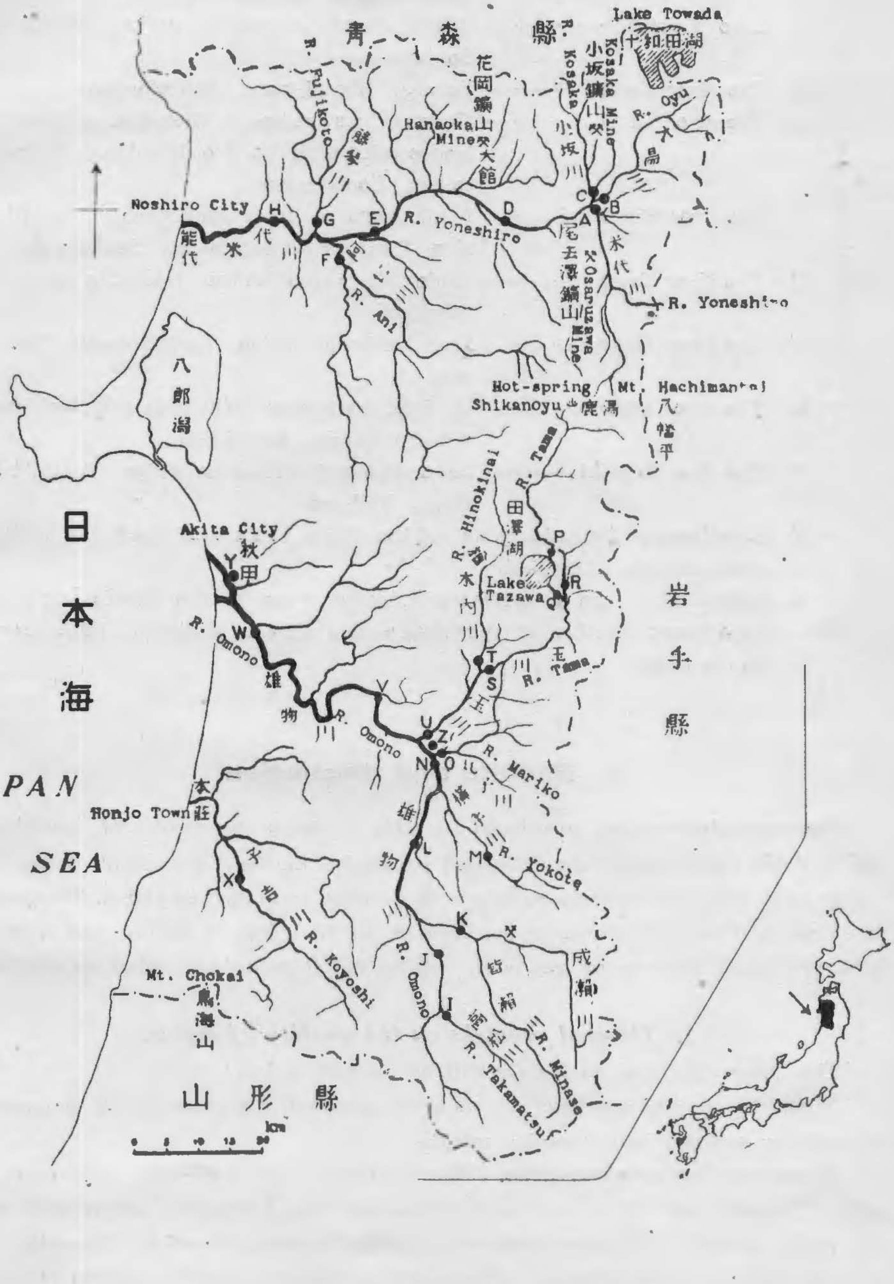
With the help and assistance of respective local agricultural association, sample water was taken simultaneously at every place, regardless of weather, on the 15th of each month.

The samples were sent to the author regularly. Chemical investigations on the water quality were continued for 12 months, from April 1942.

In choosing places, reference was made to topographical and geological maps to obtain suitable places. Unequality of water quality at both sides of lower part adjacent to confluence point, facility of movement, hydroelectric plants, position of irrigation dams, drainage from towns, and influx of polluted water from mines or factories were all points taken into consideration. Sample water was taken from centre of river where the current was fast ane deep by making use of a boat, bridge, dam or other constructed object.

Hard glass bottles with glass plugs were used as containers after being washed with sulfuric bichromate.

	Names of rivers.	*Places of sample water taken.*
The river Yoneshiro and its water system	A. The river Yoneshiro	Under Kanda bridge, Nishiki-mura, Kazuno-gun.
	B. The river Oyu	Under Furukawa bridge, Kemanai-cho, Kazuno-gun.
	C. The river Kosaka	Lower stream from Setaishi bridge, Kemai-cho, Kazuno-gun.
	D. The river Yoneshiro	Under Ogita bridge, Ogita-cho, Kitaakita-gun.
	E. The river Yoneshiro	Near Takanosu-cho, Kitaakita-gun.
	F. The river Ani	Upper stream from Takanaga bridge, Shimoono-mura, Kitaakita-gun.
	G. The river Fujikoto	Upper stream from railway bridge, of Owu main line, Niageba-mura, Yamamoto-gun.
	H. The river Yoneshiro	Lower stream from Tomine bridge, Tomine-mura, Yamamoto-gun.
	I. The river Takamatsu	Tohira, Takamatsu, Sukawa-mura, Okatsu-gun.
	J. The river Omono	Under bridge between Yamada and Yuzawa-cho, Okatsu-gun.
	K. The river Minase	Sennen lock-gate, Iwasaki-cho, Okatsu-gun.
	L. The river Omono	Nishitoyaba, Tateai-mua, Hiraka-gun.
	M. The river Asahi (or Yokote)	Ninokuchi,. Yokote-cho, Hiraka-gun.
	N. The river Omono	Ferry between Hirukawa and Omagari-cho, Senboku-gun.
	O. The river Mariko	Lower stream from Maruko bridge, Omagri-cho, Senboku-gun.


Lake Towada
青 森 縣
十和田湖
R. Fujikoto
R. Kosaka
Kosaka Mine
花岡鑛山
Hanaoka Mine
大館
小坂鑛山
小坂川
R. Oyu
大湯
Noshiro City
能代
米
代
川
R. Yoneshiro
尾去澤鑛山
Osarizawa Mine
米代川
R. Yoneshiro
R. Ani
阿仁
八郎潟
Hot-spring
Shikanoyu
鹿湯
Mt. Hachimantai
八幡平
R. Tama
R. Hinokinai
田澤湖
Lake Tazawa
檜木内川
Akita City
秋田
日本海
岩手縣
R. Omono
雄物川
玉川
R. Tama
R. Omono
R. Mariko
JAPAN
SEA
本荘
Honjo Town
R. Yokote
子吉
R. Koyoshi
成瀬川
Mt. Chokai
鳥海山
R. Omono
R. Takamatsu
R. Minase
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km
0 5 10 15 20
A B C D E F G H I J K L M N O P R S T U V W X Y Z

The river Omono and its water system

P. The river Tama ··············· At tunnel between river Tama and Lake Tazawa, Tazawa-mura, Senboku-gun.

Q. Lake Tazawa ··················· Obonai electric generating station, Obonâi-mura, Senboku-gun.

R. The river Tama ··············· Funaba, Obonai-mura, Senboku-gun.

S. The river Tama ··············· Under Oitoku bridge, 1 kilometre up from confluence point with the river Hinokinai, Kakunodate-cho, Senboku-gun.

T. The river Hinokinai ········ 1 kilometre up from confluence point with the river Tama, Kakunodate-cho, Senboku-gun.

U. The river Tama ··············· Under Tamagawa bridge, Hanadate-mura, Senboku-gun.

V. The river Omono ············ Near Kariwano bridge, Kariwano-cho, Senboku-gun.

W. The river Omono ············ Up from confluence point with the river Iwami, Yotsugoya-mura, Kawabe-gun.

X. The river Koyoshi ············ Lower stream from Nagase bridge, Nishitakizawa-mura, Yuri-gun

Y. Experimental irrigation water of the Akita Prefectural Agricultural Experiment Station, Akita-shi.

Z. Omura dam, the experimental irrigation water of the Tohoku Agricultural Experiment Station of Agriculture and Forest Ministry, Hanadatemura, Senboku-gun.

V. Results and discussion.

The numerical values mentioned in table 1 shows the results of investigation and analysis which the author conducted for twelve months, beggining April, 1942. Sample water was taken regularly once a month from the said places. The quantity of every constituent is shown on the basis of mg in 1 litre of water, and as to turbidity Pulfrich's photometer was used, taking the Zeiss turbidity glass as standard.

1. *General remarks on the quality of water.*

The characteristic of each river will be referred to later on.

First, the general tendency of water quality will be surveyed by the average values from analysis during twelve months.

Hydrogen ion concentration. This is between pH 3.0— 6.8, and except so called inorganic acid rivers such as the Tama and the Takamatsu which show specially strong acidity, all others show weak acidity between 6.0— 6.8. Generally, pH of river water is much affected by chemical constituents chiefly calcium carbonate. If this be more present, water shows alkaline reaction; if less, water inclines to show acid or neutral reation. That the rivers in Akita prefecture commonly show weak acid reaction is due to the small quantity of calcium carbonate present in the water.

Lime (CaO) 6.2—25.1 mg/l, showed that the river Kosaka is the highest in this respect. This is due to the fact that the large amount of calcium sulfate contained therein is the result of the flowing in of mine-polluted water. Except this river, 12 mg/*l* is the highest. It can be seen that the degree of lime contained is low, compared with other rivers in Japan which shall be reported later.

Thus the rivers in Akita prefecture are not only low in content of lime, but on the other hand they contain comparatively much sulfate and chloride which combine with calcium, and eventually this results in a very small amouut of calcium combined with carbonic acid. This accounts for the tendency of acid reaction of the water.

This point is a notable feature common to all rivers in Akita prefecture.

In consequence, as the quantity of calciun carbonate naturally supplied through river water in paddy fields in Akita prefecture is small in contrast to those in the basins of other rivers in Japan, the soil must be apt to be acidic. This has actually been shown in the results of investigations of soil by engineer YAMAMOTO on the acidity of soil in paddy fields in this prefecture.

Magnesia (MgO). Except such rivers as the Kosaka and the Takamatsu, the majority of rivers are around 3 mg/*l*.

Soda (Na_2O) is 6.3—13.0 mg/*l* and excepting those rivers along the river Tama there is a general tendency of containing somewhat much.

Potash (K_2O). It is 0.65—2.22 mg/*l*. In general a little low tendency is seen. Potash could not be found to such a rarely high degree as that in the river Shira in Kyushu.

The highest figures were found in the river Takamatsu which is strongly acid, and in the irrigation water of the Akita Prefectural Agricultural Experiment Station, into witch drains might have flowed.

The lowest were in lake Tazawa, the river Hinokinai, middle and lower parts of the river Tama and irrigation water of the Tohoku Agricultural Experiment Station of Agriculture and Forest Ministry. There is not any notable differences among the rest; the average value was about 1.1mg/*l*.

Carbonic acid (CO_2). This is calculated from bicarbonate and carbonate alkalinity. No wonder that the special rivers Tama and Takamatsu do not contain any carbonic acid, and all others no more than 3.2—9.3 mg/*l*.

It was made clear specially that carbonic or bicarbonic calcium was found very rarely in the rivers of Akita prefecture.

Sulfuric acid (SO_3) is 5.4—51.1 mg/*l*. The river Kosaka, upper and middle parts of the river Yoneshiro, and the river Takamatsu are of notably high figures. And also in other rivers there is an extraordinary trend to find that sulfate is of a higher rate than that carbonate.

Chlorine (Cl) is 6.4—52.9 mg/*l*. It is very high in the river Takamatsu and the upper part of the river Tama, both of which are strongly acid. However, medium ones show more or less than 10 mg/*l* and figures of chloride as well as sulfate are higher than average.

Silica (SiO_2). The highest is 34.9 mg/*l* for the river Oyu while the lowest is 7.5 mg/*l* at lake Tazawa, and 15—20 mg/*l* for most of other rivers.

There is a tendency for it to be high in those rivers subordinate to the river Yoneshiro and its water system, and low in lake Tazawa and also in the lower parts of the river Tama downward from lake Tazawa and streams subordinate thereto.

Judging from the results of the authors investigations on many rivers in Japan, the trends are observed as follows: that in areas of those rivers short of potash and silica most paddy fields are of low productivity, in other words, yield a poor crop and easily give rise to such disease as "gomahagare".

The rivers in Akita prefecture, which might be compared to the above kind, are the middle and lower parts of the river Tama, including lake Tazawa and the river Hinokinai.

Iron (Fe_2O_3). Except 2.95 mg/*l* of the river Takamatsu, which is strongly acid, all others are between 0.01—1.19 mg/*l*.

The amount of iron is generelly high in the rivers rich in organic substances.

Phosphoric acid (P_2O_5): Except for the 0.11 mg/*l* of the irrigation water in the Prefectural Agricultural Experiment Station, all are between 0—0,03 mg/*l*.

The least amount is found in those rivers belonging to the water system of the rivers Yoneshiro and Tama.

Nitrate nitrogen (NO_3—N) is 0.02—0.32 mg/*l*; but except for irrigation water of the Prefectural Agricultural Experiment Station, the others are mostly low.

Ammonia nitrogen and albuminoid nitrogen. Both included mostly are around 0.1 mg/*l*.

Organic substances ($KMnO_4$ quantity consumed) are 1.5— 9.6 mg/*l*; where drainage flows in, of course figures rise, but geneally slow streams on fertile flat regions are high as, for instance, the river Mariko, a tributary to the river Omono. Turbidity in these rivers is high and at the same time nitrogen, phosphoric acid and iron are much in evidence.

Dissolved residue. Excepting 171.6 of the river Takamatsu which is strongly acid and 164.8 of the river Kosaka which contains polluted water of mines, all others are 51.6— 114.1 mg/*l*.

In the lower part of the river Tama and its tributary, downwards from lake Tazawa, dissolved residues are very little, due to scarcity of various chemical constituents therein.

Suspended residue and turbidity. The river Kosaka and the middle part of the river Yoneshiro are abnormally turbid, affected by polluted water from mines, whereas water in rivers along the river Tama and also the rivers Ani and Fujikoto are clear and of least turbidity.

2. *Characteristics of the river Yoneshiro and its water system.*

There are many famous copper mines in this area such as Kosaka and Osarusawa, and therefore polluted water from these gave rise to serious social problems in olden times and some of them were widely known as poisonous water. Though most of these mines have their institutions and means to dispose of polluted water since then, yet in the rivers Kosaka and the Yoneshiro after joining the river Kosaka as far as Odate town, an extraordinary water quality is found in present days.

As shown under C and D figures on sulfuric acid, suspended residue and turbidity are very high and moreover copper is found in suspended substances. Of course such water is not suitable for irrigation.

But putting aside those abnormal points, in columns of A, B, E, F, G, H, that is on the quality of water in the lower stream of the river Yoneshiro and also the rivers Oyu, Ani and Fujikoto, many common points are found as shown in table 1. Accordingly this quality represents not only that of the river Yoneshiro and its tributaries but also it can be taken as a normal quality in the north Akita region.

To mention common features, the reaction is weakly acid; there is a scarcity in carbonate; much sulfate is present; and the water is rich in silica.
All these points are mostly similar with those same features of other rivers in this prefecture, but show a little higher figure in silica.

8. *Characteristics of the river Omono and its water system.*

Excepting special tributary rivers of the Takamatsu and the Tama, both of which are strongly acidic, T, L, N, V, W, of the main stream and tributary rivers Minase, Yokete (or Asahi), Mariko etc. are of nearly the same quality of water. Looking at the table 1 on the average figures (on mg/l) during twelve months, CaO 8.7—11.4, MgO 3.0—4.3, Na_2O 10.0—13.0, K_2O 0.87—1.33, CO_2 3.2—8.8, SO_3 9.5—15.0, Cl 8.4—16.8, SiO_2 14.2—18.8 and pH 6.0—6.8 are shown.

It can be concluded from the above figures that the several rivers along the river Omono which represents river water in the middle and south eastern region of Akita prefecture are equal to the above-mentioned river Yoneshiro; their special features lie in scarcity of carbonic calcium, much sulfate and chloride, and lastly reaction of weak acid.

Thus it follows that all the rivers along the rivers Yoneshiro and Omono, the main stream in the area of Akita prefecture, resemble each other is attributable, among other things, to the fact that the geology of the area is comparatively the same and the mountain river heads mainly consist of tertiary period stratum or andesite.

But in the cases precisely investigated, in the water qualities of the above-mentioned rivers along the river Omono, there are of course differences and peculiarities. For instance, that the water quality of the main stream of the Omono becomes somewhat diluted by joining the tributary Tama, which is thin in its constituents, can be seen by comparing V and W with L and N. Again the point will be noticed that by combining the river Takamatsu which is of strong acid quality, carbonate in J column is diminished; another point is that the tributary river Mariko, which flows down slowly across the paddy fields in the Omagari flat region, is somewhat high in turbidity, organic substances, nitrogen, phosphate, iron etc.

Some remarks will be made on the rivers Takamatsu and Tama which show special water quality as ***inorganic acid rivers.***

Quality of water in the river Takamatsu as shown in table 1 exhibits strong acid around pH 3.0 at Tohira of Sukawa-village. In the region irrigated by this river water, soils became worse and in consequence the growing of rice plants and the yield of the rice crop is very poor.

Causes of such poisonous and harmful acid in the river Takamatsu are mainly attributable to acids in the mountain stream Yushirizawa which joins near Sanzugawa at the left side of the upper part of the river Takamatsu. Acid in the stream Wasabizawa which flows down from Horai mine is another cause. Acids of Yushirizawa come in at the point where the torrents flow down near Kawarage sulfur mine, not far from its stream head. Here hot springs and gas which contain hydrochloric acid and sulfuric acid spout, and in consequence the water becomes abruptly acid.

At the time when the author investigated the original place of poisonous acid in May 1943, it was found that while mountain torrents flow down at the length of around 60 metres, in a stream volume of some 1 cubic metre per second, the quantity of Cl and SO_3 contained enormously increased, as Cl from 3.2 to 281.0 mg/l and SO_3 from 4.0 to 94.0 mg/l, while on the other hand pH decreased from 4.1 to 2.2.

It is said that for the purpose of improving such poisonous water, some works were planned in the past for preventing the flowing in of the hot spring; but unfortunately the work was left incomplete. However, there is on hand a plan at present to introduce river water from other places for irrigation and thus to avoid such harmful water. If this be accomplished damage will be considerably reduced.

Observations are next stated on the river Tama, a tributary to the river Omono, which is one of the largest acid rivers in our country and well known as "poisonous water" from ancient times.

The river Tama rises from mountain group of Yakeyama on Akita and Iwate prefectural boundaries. At Gojumagari it joins the river Shibukuro on the right bank which is the source of the poisnous water. And then it annexes such tributaries as the rivers Kowase and Sendatsu and flows down to the south along the east side of lake Tazawa, the deepest lake in our county (425 metres).

After joining the river Obonai, the middle stream of the Tama flows into the open field in the vicinity of Kakunodate town. It then joins the river Hinokinai and turns to the south west to pour into the river Omono in Hanadate village. Being the biggest tributary of the river Omono (its length being 83 miles), the river water appears pure and clear. The mountainous part in the area of this river is covered with a thick forest of broad- and needle-leafed trees aged more than 100 years.

But this clear water of the Tama contains a great quantity of hydrochloric and sulfuric acids reacting strongly.

People are afraid of this river and it has been known as "poisonous water" from old times. The main source of the poison originates in the hot spring Shikanoyu which gushes out near an old crater Yakeyama; its temperature is 98° C, and gives forth 5 cubic ft. per second in volume, reacting pH 1.0; this is equivalent to a mixture of hydrochloric acid and sulfuric acid of 0.1 normal. This spring pours into the upper part of the river Tama through the above mentioned river Shibukuro, thus causing the river water to become poisonous. Streaming down from the poisonous source, the river annexes many tributaries and, by increasing its water volume and neutralized by bicarbonate in other rivers, it becomes less poisonous. Still it shows acidity as far as the lower reaches of the stream.

On that account the soil in large areas of paddy fields irrigated by the river Tama are spoilt.

So-called inorganic acid rivers, which contain hydrochloric acid or sulfuric acid and are strongly acid, are rare in foreign countries, but such rivers are found in large numbers in the northeastern part of Japan. They spoil agrarean and aquatic and other productions.

Irrigation with such acid water turns soil of paddy fields to acid and activates alumina, in consequence severe poison not only directly hinders the growing of rice plants, but also indirectly by coagulating colloids in soil makes the ground to be porous and necessitates more irrigation of poisonous water and the soil temperature becomes low. Furthermore the perishing of microbes interrupts decomposition and dissolution of manure.

The above mentiond various bad effects hinder the growing of the rice plant and decrease its crop.

But when the author investigated damaged paddy fields in the areas of the rivers Takamatsu and Tama, he found that the following fact also constitutes a major cause for damage.

In consequence of acid water taking off iron in solution from the paddy fields which protects the rice plant roots from hydrogen sulfide, the plant shows severe decay in its root; for the same reason advocated lately by Dr. SHIOIRI, there are poor ears in decrepit paddy fields.

Accordingly as a counter measure for damage to paddy fields irrigated by acid water of the rivers Takamatsu and Tama, it is necessary not only to keep away such poisonous water by amaliorating water quality and at the same time neutralizing acid in soil with lime, but also to supply iron which is deficient by adding more mud.

There are extant many writings[2] on investigations and preventative methods for poison from past days. And among them one of most valuable data from the agricultural view point is the work by technical expert MATSUSABURO SHIOIRI of the Agricultural Experiment Station in October, 1936, - namely, investigation on the relation between quality and quantity of river water of the river Tama and its water system, nature of soil in affected paddy fields by poison, and also on effects of discharging original poisonous water underground in forests areas, as a preventative measure against poison, which was still under way of experiment at that time.

Later, as a means of setting up against poison, the original poisonous hot spring was led in and discharged into the primitive woods of Mt. Hachimantai in order to let the poisonous substances permeate into the earth, and by that, freeing the river Tama from its poisonous water. This work is progressing as a national enterprise and is as yet unfinished; however many good results have been already produced.

Furthermore there was another method of leading the Tama river water from midstream into lake Tazawa through a tunnel. This weakens poison and at the same time controls the water volume by the lake for generating electricity, and for irrigation for reclaimed land under the so-called Tazawa drainage works. The plan was accomplished by the Tohoku Development and Electricity Co. (present the Japan Generating Electricity and Supply Co.).

By these innovations water quality of the river Tama must have been greatly improved compared with that of old times.

In order to clarify these points regarding river water of the Tama and its subordinates, the author executed examination by setting up 6 places (P—U). The results are shown in table 1, and it is pH 4.2 at P of the water course which reaches lake Tazawa from the river Tama. It was pH 3.4 at the time of the technical expert SHIOIRI's investigation in 1936. By comparison with this figure it is clearly seen what beneficial results have been obtained by discharging original poisonous water.

The main poisonous constituent Cl is 31.2 mg/l, whereas after weakening through lake Tazawa it is pH 5.5 at Q and Cl contained becomes 10.9.

Again it reaches S of the upper stream from Kakunodate town, after joining the rivers Sendatsu and Obonai, it shows pH 6.2 and 8.5 mg/l of Cl contained. Accordingly it is clear that after joinig lake Tazawa, the river Kosendatsu and the river Obonai, the river water of the Tama is no more harmful for irrigation.

Moreover the density of every constituent is so improved as almost to be equivalent to that of normal water in the main stream of the river Omono.

Next, the water quality of the river Koyoshi which flows in the southwestern part of Akita prefcture is comparable to the normal water quality of the rivers Yoneshiro and Omono and their water systems as shown on Table 1.

VI. Influences of seasons and weather.

As material to observe the relation between quality of water and weather or seasons, the streaming volumes of every river on the days of taking sample water are mentioned in table 2, based upon a survey carried out by the measuring offices of the Communication Ministry.

Inorganic substances dissolved in the water of every river of Akita prefecture are at a minimum during April and May when the river water is increased due to snow thawing, whereas there is a tendency of their becoming more dense during the dry month of August. But differences in density are remarkably small compared with variation of streaming volumes.

Thus it can be seen that river water as a whole is not affected by weather or seasons and keeps its chemical individuality. But suspended substances and turbidities, quite different from dissolved chemical constituents, differ enormously even in the same river when affected by weather, climate or seasons on the day of the taking of the sample water.

VII. General comparison with river water of the world.

For the purpose of comparing water qualities of river in Akita prefecture with those averaged in the world, table 3 is calculated out according CLARKE's indication method [3] of water qualities.

The table shows the composition of dissolved inorganic components in % to their total sum of quantities (salinity), which are worked out from average values shown in table 1.

The rivers in Akita prefecture show the following characteristics when compared with the average qualities of the world, which CLARKE has pointed out, based upon water qualities of the famous European and American rivers, namely.

1. As to bases, less in calcium and more in natrium.
2. As to acid radicles, poor in carbonate and rich in sulfate and chloride.
3. One more notable characteristic is that silica is contained in far greater ratio.

VIII. Quantity of fertilizing substances supplied through irrigation

It is desirable to calculate from the above results the quantities of fertilizing substances naturally supplied through irrigation.

For that purpose it should first be determined how much water quantity is necessary for cultivating rice plants, namely water volume of permeation or filtration through soils, and evaporation from surfaces of paddy fields and rice plants; all these should be taken together. (So it does not mean actual quantity of water necessary for rice planting.) However, quantity of permeations through soils varies in great degree according to the nature of the soil in every place, and that of evaporation from surfaces of leaves and fields, also differs with the weather, species of rice plant, condition of rice crop, etc.

For the above mentioned reasons, in spite of many investigations and experiments made by agricultural scholars, the fundamental standard of necessary volume of water has not yet been ascertained. (So far the results vary from 600,000 gallons to 2,300,000 gallons per acre.)

But according to the official engineer of the Home Ministry SHO MIZUTANI [4], the necessary quantity of water in a mean field of our country is said to be 0.0014—0.002 cubic metres per second for 1 cho (about 2.45 acres). If irrigation be continued at the mean of this quantity for 100 days it comes to some 1,600,000 gallons for 1 acre of field. In case one litre of irrigation water contains 1 mg of fertilizing substance, the amount of fertilizer supplied equals around 6 kg for 1 acre.

On the basis of the above results of analysis, the figures in respect of quantity of supplied fertilizing substances can be worked out as follows:

First, as to potash, from 4 kg to 13.3 kg per 1 acre and 6.6 kg in case of a mediocre river. Potash contained in rivers of Akita prefecture is 1.1 mg/l on average, so it is to be presumed some 2,000,000 kg in total would be supplied for the whole 300,000 acres of paddy fields in this prefecture, that is to say it is equivalent to 4,600 tons of sulfate of potash.

In the same manner an estimation on nitrogen is some 300,000 kg, corresponding to 1,500 tons of sulfate of ammonia. Silica supplied in dissolved form in river water is 45—210 kg per 1 acre, so it amounts to some 30,000 tons for the entire paddy fields in this prefecture.

Calcium carbonate is of small quantity as afore mentioned, but except in the case of such special acid rivers as the Takamatsu and the Tama, 40—120 kg per acre and 20,000 tons are supplied to the whole area of fields in the prefecture.

It can be realized from the above figures that the quantity of fertilizing substances naturally supplied are never small. *

IX. Methods of analysis.

At analysing, such operations as filtration, washing, titration etc. are all dependent upon the microanalytic method which was contrived by Dr. MATSUSABURO SHIOIRI. (5) (6)

As to the colorimetric method Pulfrich's photometer was used to measure thickness of colors. It was very advantageous and convenient to adopt these methods because a comparatively small quantity of water will answer for the purpose and moreover accurate and correct results of analysis could be obtained.

The following are the methods of analysis which the author has adopted.

Lime.(5) To precipitate as oxalate and filter. After dissolution of precipitate in sulfuric acid, titrate with potassium permanganate.

Magnesia.(5) Filtrate of separated lime is used to precipitate as oxychinolinate. After filtering and washing, dissolved in hydrochloric acid and then titrated with potassium bromate and sodium thiosulfate.

Soda.(5) To precipitate with zinc uranyl acetate. After filtering and washing, dried at room temperature and then to be measured.

Potash.(7) (8) To add a drop of sulfuric acid, evaporate to driness in a platinum dish and then heat to dull red. Thus after elimination of ammonia and organic substances it is precipitated as potassium platinic chloride, and after filtration and dissolution in hot water potassium iodide is added to get red wine color which is titrated with sodium thiosulfate.

Carbonic acid. To calculate from alkalinity which is obtained by titrating with acid and brome-cresol-green up to pH 4.3.

Sulfuric acid.(9) To determine by means of micro titration method using benzidine.

Chlorine. Titration method with silver nitrate solution.

Silica. Colorimetric method by using ammonium molybdate and sulfuric acid.

Iron. After oxidation, by colorimetric method with potassium thiocyanate.

Phosphoric acid. Colorimetric method with ammonium molybdate and stannous chloride.

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* How great a percentage of these substances can really be absorbed by the rice plant as nourishment ?

Of course it is very difficult to find out the percentage, but the coefficient of the aspiration (ratio of the water absorbed by a plant during its period of growth to the dry matter produced) of the rice plant is supposed to be about 750 according to the experimental researches made by LYMAN J. BRIGGS and H. L. SHANTZ (J. Agric. Research. Vol. 3, 1914) and others. (Agricultural Technique in the Soviet Union, by KENICHI KOHARA, P 260)

On the basis of this calculation, it can be said that about 50 percent of the whole amount of the nourishments mentioned above will be absorbed by the rice plant.

Nitrate nitrogen. Colorimetric by means of diphenylamine method.

Ammonia nitrogen and albuminoid nitrogen. To determine by Nessler's reagent after distillation.

pH. By colorimetric method.

X. Summary.

1. To observe the general trend of qualities of irrigation water in the area of Akita prefecture, the main 26 points on the river had been chosen where sample water was taken once every month from April 1942 on, and chemical analysis made thereof.

2. It is true that the characteristic of river water is, in most cases, determined by geology and nature of soil in its gathering area; but also, weather, hot springs, communities, mines, industry, and organic things are other conditions that influence irrigation water.

3. The remarkable characteristics common to every river in Akita prefecture are: the predominance of sulfate and chloride the small presence of calcium carbonate; the weak reaction of acid; and the great quantity of silica.

4. Quantity of fertilizing substances naturally supplied through irrigation, are as follows:

During a rice planting period in summer time, potash is 4—13.3 kg for 1 acre; silica 45—210 kg; calcium carbonate 40—120 kg.

When these figures are extended to the paddy fields of 300,000 acres over the entire Akita prefecture, it comes to an enormous amount; viz. as for potash, corresponding 4,600 tons of sulfate of potash; nitrogen, 1,500 tons of sulfate of ammonia; lime, 20,000 tons of calcium carbonate, and 30,000 tons of silica.

5. From investigations made so far on many rivers in Japan, it can be concluded that many paddy fields, in areas of rivers scarce of potash and silica, are inclined to be low in their productivity and turn to the so-called "Akiochi paddy field" (poor yield) which easily subordinates itself to disease such as "Gomahagare."

The middle and lower stream of the river Tama and its irrigation system come under this category in Akita prefecture.

6. Dissolved inorganic matter of rivers in this prefecture is diluted to the utmost between April and May because volume of river water is increased, due to snow-thawing, but becomes concentrated in the month of August when river water is low. But the difference in the density of water is extremely small when compared with variations in stream volume or turbidity.

Accordingly, it can be said that river water, as a whole, is not so affected by weather or seasons as to lose its chemical individuality.

7. Investigations are made on rivers of strong acidity, as the so-called inorganic acid rivers of Takamatsu and Tama. The causes of damage in cultivating rice plants and counter measures taken are also under investigation.

Table 1. Analytical Results.

Places of sample warter taken	Days of sample water taken	CaO mg/l	MgO mg/l	Na_2O mg/l	K_2O mg/l	CO_2 mg/l	SO_3 mg/l	Cl mg/l	SiO_2 mg/l	Fe_2O_3 mg/l	P_2O_5 mg/l	NO_3-N mg/l	NH_4-N mg/l	Albuminoid-N mg/l	$KMnO_4$ consumed mg/l	Dissolved residue mg/l	Suspended residue mg/l	Turbidity measured with Pulfrich photometer	pH
A	III 15,1942	6.7	2.8	7.4	0.64	4.0	9.9	7.1	18.6			0.15	0.04	0.01	4.5	51	23	0.0030	6.4
	V 15,	6.8	3.5	7.0	0.82	3.7	11.0	6.0	19.4			0.09	0.04	0.02	3.6	74	7	0.0024	6.5
	VII 15,	10.8	3.5	9.3	0.98	6.6		6.1	22.6			0.10	0.01	0.16	3 1	96	4	0.0015	6.6
	VIII 15,	17.0	5.2	9.7	1.04	8.3	31.4	7.1	25.5			0.07	0.01	0.01	1.5	113	1	0.0049	6.6
	IX 15,	9.3	3.3	8.9	0.66	4.4	15.0	5.7	20.8		0.01	0.11	0.04	0.14	7.9	90	4	0.0106	6.4
	X 15,	11.4	3.5	9.0	0.95	5.7	22.0	6.8	23.6	0.18	0	0.09	0.04	0.08	2.8	81	5	0.0020	6.6
	XI 10,	14.6	4.1	9.4	0,73	4.8	20.6	6.8	20.9	0.30	0.01	0.09	0.03	0.10	3.1	87	15	0.0029	6.5
	XII 10,	12.0	3.2	7.6	0.79	5.2	18.2	7.1	21.2	0.03	0	0.02	0.02	0.06	3.1	88	104	0.0640	6.6
	I 8,1943	13.4	4.1	6.4	0.67	5.0	21.5	6.9	20.8	0.18	0.01	0.08	0.03	0.10	12.6	89	133.7	0.0371	6.4
	II 15,	12.4	3.4	8.3	0.57	4.4	24.9	8.6	18.0	0.40	0	0.14	0.02	0.05	2.4	111	6.3	0.0026	6.5
	III 15,	12.9	5.5	9.7	1.08	5.1	22.0	8.1	21.5	0.27	0	0.17	0.03	0.07	1.9	112	4.0	0.0028	6.5
	Mean	**11.6**	**3.8**	**8.4**	**0.81**	**5.2**	**19.7**	**6.9**	**21.2**	**0.23**	**0**	**0.10**	**0,03**	**0.07**	**4.2**	**90.2**	**27.9**	**0.0122**	**6,5**
B	III 15,1942	7.7	2.7	8.7	0.90	5.7	8.9	6.7	34.2			0.11	0.02	0.07	5.2	67	20	0.0074	6.6
	V 15,	8.9	3.5	10.6	1.23	.6.9	12.8	8.2	40.2			0.06	0.02	0.04	2.8	90	3	0.0017	6.7
	VII 15,	8.0	2.7	11.5	0.86	8.3		7.5	36.3			0.09	0.01	0.12	6.0	113	22	0.0035	6.7
	VIII 15,	12.6	2.4	11.1	0.95	9.8	12.6	7.9	41.5			0.06	0.03	0.05	5.4	107	1	0.0021	6.7
	IX 15,	9.1	2.7	9.8	0.91	6.6	24.2	5.7	32.5		0 02	0.08	0.02	0.07	9.6	89	27	0.0120	6.8
	X 15,	8.5	2.6	9.8	0.93	8.1	11.9	7.1	36.2	0.03	0.02	0.01	0.04	0.06	3.3	96	3	0.0020	7.0
	XI 10,	9.3	1.6	12.4	0.82	8.0	12.2	7.5	34.3	0.04	0.01	0.05	0.03	0.10	1.1	89	7	0.0009	6.8
	XII 10,	8.1	2.1	9.3	0.77	6.7	11.4	7.6	31.9	0.04	0.01	0	0	0.06	0.8	99	2	0.0011	6.7
	I 8,1943	7.9	2.4	9.8	0.86	7.7	12.7	8.3	32.5	0.02	0.01	0.02	0.02	0.05	2.8	98	5.1	0.0013	6.8
	II 15,	9.0	3.3	10.5	0.82	8.0	11.8	10.1	38.0	0.14	0.02	0.11	0.03	0.05	1.3	96	1.3	0.0011	6.7
	III 15,	9.4	3.2	13.3	1.01	7.7	9.9	9.7	26.0	0.02	0	0.03	0.02	0.04	1.1	109	1.0	0.0011	6.5
	Mean	**9.0**	**2.7**	**10.6**	**0.91**	**7.6**	**12.8**	**7.9**	**34.9**	**0.05**	**0.01**	**0.06**	**0.02**	**0.07**	**3.6**	**95.7**	**8.4**	**0.0031**	**6.7**
C	III 15,1942																		
	V 15,	22.4	6.2	9.8	1.05	0,7	56.9	9.9	28.4			0.12	0.10	0.07	8.6	154	19	0.0348	4.5
	VII 15,	19.4	5.9	10.1	0.98	6.9		7.8	28.1			0.18	0.01	0.17	4.1	147	22	0.0080	6.6
	VIII 15,	31.0	8.6	13.6	1.70	2.9	56.2	8.6	32.3			0.18	0.04	0.09	4.7	184	43	0.0240	6.0
	IX 15,	13.5	4.6	9.4	1.22	0.9	34.8	5.4	26.5		0	0.11	0.02	0.07	8.3	123	34	0.0290	5.2
	X 15,	18.8	6.1	9.5	1.18	6.2	39.2	7.1	28.3	0.75	0	0.12	0.12	0.07	2.3	134	19	0.0126	6.7
	XI 10,	20.0	5.4	12.2	1.38	3.0	44.0	8.2	26.3	0.03	0	0.16	0 04	0.11	6.7	152	32	0.0195	6.0
	XII 10,	22.5	7.0	10.7	1.07	2.1	51.4	7.4	26.5	0.04	0	0.01	0.02	0.05	1.1	165	19	0.0219	5.9
	I 8,1943	31.5	7.1	9.6	1.09	9.0	48.2	9.4	26.1	1.07	0.01	0.08	0.03	0.07	13.0	167	353.7	0.0710	6.9
	II 15,	40.6	9.9	10.5	1.30	10.8	66.1	12.5	27.0	1.05	0.01	0.20	0.03	0.06	18.5	201	1211.3	0.2452	6.8
	III 15,	31.2	11.5	13.3	1.43	4.3	62.9	10.3	24.0	0.51	0	0.25	0.04	0.27	12.4	221	1801.0	0.1860	6.2
	Mean	**25.1**	**7.2**	**10.9**	**1.24**	**4.7**	**51.1**	**8.7**	**27.4**	**0.58**	**0**	**0.14**	**0.06**	**0.10**	**8.0**	**164.8**	**355.4**	**0.0652**	**6.1**

D	III 15, 1942	7.8	2.7	8.3	0.70	3.0	15.5	7.8	24.0			0.12	0.01	0.02	2.9	90	15	0.0076	6.2
	V 15,	9.2	4.0	8.3	1.21	3.3	19.8	7.1	22.2			0.11	0.05	0.06	4.9	88	9	0.0054	6.3
	VII 15,	12.4	3.4	11.3	3.29	5.5		7.5	27.4			0.69	0.01	0.07	7.1	114	10	0.0038	6.3
	VIII 15,	15.3	4.8	9.4	3.42	2.6	55.2	6.4	25.8			0.39	0.20	0.21	27.7	141	158	0.1924	6.2
	IX 15,	10.9	3.6	9.5	2.33	4.0	21.6	5.7	25.5		0.18	0.09	0.05	0.14	9.9	108	40	0.0208	6.2
	X 15,	11.4	4.0	9.8	1.63	5.1	25.0	7.5	25.8	0.65	0.01	0.04	0.10	0.11	3.6	106	21	0.0062	6.6
	XI 10,	11.7	4.9	11.4	1.99	4.8	25.8	7.8	26.2	0.29	0	0.10	0.05	0.07	4.4	112	21	0.0059	6.5
	XII 10,	11.0	4.3	10.0	1.95	3.6	38.7	8.0	24.2	0.65	0	0.01	0.04	0.12	1.2	129	14	0.0073	6.4
	I 8, 1943	16.5	5.5	11.2	1.40	5.8	26.2	9.4	27.3	0.56	0.01	0.09	0.03	0.08	11.1	112	30.1	0.0146	6.6
	II 15,	15.4	6.4	11.5	1.03	5.8	30.6	10.1	24.0	0.72	0.01	0.20	0.03	0.04	1.9	118	32.5	0.0165	6.7
	III 15,	15.2	6.1	12.7	1.22	3.3	33.3	10.0	23.0	0.25	0	0.16	0.02	0.06	2.7	137	12.0	0.0070	6.5
	Mean	**12.4**	**4.5**	**10.3**	**1.83**	**4.3**	**29.2**	**7.9**	**25.0**	**0.52**	**0.03**	**0.18**	**0.05**	**0.09**	**7.0**	**114.1**	**33.0**	**0.0261**	**6.4**
E	III 15, 1942	8.2	3.6	8.4	0.76	3.1	15.7	5.0	19.8			0.14	0.01	0.07	6.0	76	31	0.0090	6.2
	V 15,	9.1	3.8	8.7	0.80	2.3	20.3	7.8	21.2			0.11	0.03	0.08	4.4	75	13	0.0076	6.4
	VII 15,	11.7	4.9	11.1	0.95	6.8		9.8	22.5			0.17	0	0.05	2.6	108	2	0.0022	6.5
	VIII 15,	17.1	5.8	12.3	1.34	7.9	31.6	10.0	28.3			0.30	0.01	0.20	1.5	131	3	0.0017	6.4
	IX 15,	9.2	3.1	10.1	1.06	4.2	16.6	6.4	22.3		0	0.10	0.03	0.07	11.5	94	10	0.0109	6.5
	X 15,	12.1	4.4	10.2	1.25	5.9	23.7	8.2	25.2	0.25	0	0.07	0.04	0.05	2.0	103	5	0.0028	6.6
	XI 10,	11.0	4.2	14.1	1.81	5.8	19.8	10.6	20.7	0.38	0.03	0.23	0.05	0.07	3.7	100	10	0.0024	6.7
	XII 10,	10.3	4.6	15.3	1.49	5.5	17.5	10.3	25.3	0.23	0.01	0.24	0.07	0.06	3.7	115	7	0.0015	6.4
	I 8, 1943	12.8	5.1	10.2	0.97	5.2	24.7	9.0	24.8	0.19	0	0.09	0.02	0.04	2.7	99	11.6	0.0055	6.5
	II 15,	13.8	5.6	10.7	0.99	4.9	26.1	11.4	24.0	0.17	0	0.12	0.03	0.06	1.9	117	11.7	0.0068	6.3
	III 15,	12.3	5.2	12.6	1.14	3.3	21.4	11.3	18.8	0.27	0	0.16	0.03	0.06	3.3	117	23.0	0.0138	6.4
	Mean	**11.6**	**4.6**	**11.3**	**1.14**	**5.0**	**21.7**	**9.1**	**23.0**	**0.25**	**0.01**	**0.16**	**0.03**	**0.07**	**3.9**	**103.2**	**11.6**	**0.0058**	**9.5**
F	III 15, 1942																		6.6
	V 15,	5.0	2.7	7.5	0.81	5.7	6.1	8.5	13.2			0.02	0.03	0.05	2.0	52	2	0.0011	6.6
	VII 15,	9.5	4.0	11.2	0.90	10.1		9.8	16.0			0.06	0.01	0.18	2.3	78	1	0.0006	6.6
	VIII 15,	13.8	5.1	9.7	1.16	10.1	3.8	7.9	18.0			0.05	0.03	0.06	5.6	77	3	0.0015	6.7
	IX 15,	7.8	2.4	9.0	0.72	7.9	5.6	7.9	17.0		0	0.05	0.02	0.05	1.1	76	1	0.0012	6.8
	X 15,	8.4	3.4	8.8	0.88	8.8	8.5	9.6	16.0	0.02	0	0.01	0.02	0.06	2.0	68	1	0.0010	6.8
	XI 10,	7.2	2.9	10.3	0.90	7.1	6.0	9.2	14.0	0.04	0	0.01	0.03	0.06	2.8	66	14	0.0017	6.7
	XII 10,	7.1	3.0	10.4	0.63	6.0	6.3	11.3	16.1	0.03	0	0	0.02	0.05	3.4	68	4	0.0073	6.7
	I 8, 1943	10.4	3.9	9.8	0.93	8.3	6.8	10.9	17.5	0.05	0	0.02	0.02	0.05	0.2	68	3.5	0.0008	6.7
	II 15,	8.9	4.3	11.3	0.80	8.4	9.5	13.2	15.0	0.05	0	0.06	0.02	0.05	1.6	74	3.8	0.0034	6.7
	III 15,	9.1	5.4	12.2	0.95	8.0	7.7	12.6	16.0	0.07	0.01	0	0.02	0.06	1.5	87	1.0	0.0008	6.7
	Mean	**8.7**	**3.7**	**10.0**	**0.87**	**8.0**	**6.7**	**10.1**	**15.9**	**0.04**	**0**	**0.03**	**0.02**	**0.07**	**2.3**	**71.4**	**3.4**	**0.0019**	**6.7**
G	III 15, 1942	8.2	3.0	9.4	1.09	6.8	4.7	10.6	16.6			0.07	0.04	0.06	1.3	59	6	0.0009	6.7
	V 15,	8.6	3.6	9.2	0.81	7.3	10.5	9.9	14.8			0.02	0.03	0.07	0.8	63	1	0.0006	6.7
	VII 15,	11.1	4.2	10.5	1.06	10.1		9.8	17.1			0.02	0	0.08	1.1	81	1	0.0013	6.8
	VIII 15,	15.0	5.6	12.7	1.50	12.5	11.3	11.4	18.8			0.06	0.04	0.09	1.5	100	1	0.0049	6.6
	IX 15,	10.9	3.6	11.7	1.18	6.6	9.8	10.0	20.3		0.01	0.03	0.02	0.07	3.4	94	1	0.0013	6.8
	X 27,	11.2	3.8	9.4	1.20	9.5	12.1	10.7	18.3	0.03	0	0.01	0.05	0.08	1.5	81	3	0.0008	6.8
	XI 10,	9.9	3.4	12.8	1.38	9.0	9.3	10.2	16.0	0.02	0	0.05	0.04	0.07	1.5	85	3	0.0009	6.9
	XII 10,	9.2	4.2	12.6	1.22	8.3	10.0	12.2	18.1	0.04	0	0	0.02	0.04	1.1	93	3	0.0024	6.8
	I 8, 1943	11.3	4.8	11.9	1.29	9.8	11.5	14.5	19.3	0.02	0.01	0	0.02	0.04	1.9	86	3.1	0.0008	6.8
	II 10,	12.4	5.4	13.7	1.27	9.5	12.4	16.9	21.5	0.03	0.01	0.11	0	0.05	1.3	100	1.3	0.0008	6.7
	III 10,	12.7	5.3	15.6	1.50	9.3	13.0	16.5	19.5	0.04	0	0.06	0.02	0.06	1.1	105	1.0	0.0012	6.6
	Mean	**11.0**	**4.3**	**11.8**	**1.23**	**9.3**	**10.5**	**12.1**	**18.2**	**0.03**	**0**	**0.04**	**0.03**	**0.07**	**1.5**	**86.1**	**2.2**	**0.0014**	**6.8**

Table 1. Continued.

Places of sample water taken	Days of sample water taken	CaO mg/l	MgO mg/l	Na_2O mg/l	K_2O mg/l	CO_2 mg/l	SO_3 mg/l	Cl mg/l	SiO_2 mg/l	Fe_2O_3 mg/l	P_2O_5 mg/l	NO_3-N mg/l	NH_4-N mg/l	Albuminoid-N mg/l	$KMnO_4$ consumed mg/l	Dissolved residus mg/l	Suspended residue mg/l	Turbidity measured with Pulfrich photometer	pH
H	III 15, 1942	6.9	3.1	8.8	0.70	4.4	10.1	9.9	18.6			0.12	0.01	0.02	3.1	62	12	0.0065	6.5
	V 15,	6.8	3.3	8.2	1.00	4.6	11.4	8.2	16.0			0.06	0.06	0.08	4.7	67	4	0.0022	6.6
	VI 15,	11.3	2.7	11.3	1.11	7.8		9.5	20.2			0.14	0	0.10	2.6	98	5	0.0019	6.6
	VII 18,	13.8	4.8	9.9	0.90	5.3	17.8	7.9	20.5			0.21	0.03	0.15	10.2	87	30	0.0202	6.4
	IX 15,	7.6	2.6	9.1	1.04	4.4	12.7	6.4	19.0		0.01	0.12	0.03	0.12	10.9	80	38	0.0222	6.6
	X 15,	12.6	3.8	10.4	1.29	7.0	19.3	8.9	21.5	0.17	0	0.01	0.04	0.08	2.3	112	2	0.0022	6.7
	XI 10,	10.5	3.4	12.6	0.93	6.2	12.8	9.6	18.6	0.21	0	0.09	0.03	0.07	2.8	82	5	0.0021	6.7
	XII 10,	10.0	3.5	12.9	1.41	6.1	14.5	11.5	19.7	0.09	0	0.01	0.03	0.07	3.7	90	11	0.0192	6.5
	I 8, 1943	13.5	5.2	8.6	1.22	7.0	16.8	11.2	24.3	0.10	0	0.02	0.02	0.05	0.8	92	4.2	0.0039	6.7
	II 15,	11.1	5.5	11.3	1.01	6.6	18.5	13.6	23.0	0.42	0	0.11	0.02	0.07	2.8	99	5.8	0.0047	6.7
	III 15,	11.3	5.1	11.5	1.39	5.8	19.4	11.9	18.5	0.20	0	0.12	0.04	0.07	2.2	111	6.0	0.0037	6.6
	Mean	**10.5**	**3.9**	**10.4**	**1.09**	**5.9**	**15.3**	**9.9**	**20.0**	**0.20**	**0**	**0.09**	**0.03**	**0.08**	**4.2**	**89.1**	**11.2**	**0.0081**	**6.6**
I	III 15, 1942	6.8	4.5	7.1	1.07	0	15.3	22.0	27.0			0.06	0.02	0.03	3.3	82	7	0.0030	3.5
	V 15,	8.0	5.1	7.8	1.54	0	23.4	33.7	30.6			0.07	0.02	0.03	2.3	100	4	0.0015	3.0
	VI 15,	12.2	8.1	8.6	1.89	0		46.8	34.6			0.09	0	0.04	3.6	167	2	0.0019	3.1
	VII 15,	21.2	17.8	15.2	2.60	0	52.6	88.6	46.4	4.20		0.05	0.05	0.01	3.4	279	3	0.0004	2.8
	IX 15,	13.5	8.3	12.5	2.43	0	33.7	52.9	37.5	2.62	0.01	0.06	0.02	0.17	8.9	199	9	0.0044	2.9
	X 15,	13.0	6.9	12.9	2.43	0	35.2	53.6	31.6	2.00	0.01	0.02	0.04	0.08	2.0	90	4	0.0016	2.9
	XI 10,	13.5	5.0	13.0	1.75	0	27.1	41.6	28.1	2.34	0.02	0.05	0.02	0.07	2.1	130	8	0.0018	2.9
	XII 10,	11.0	5.9	10.3	2.02	0	30.8	55.9	27.5	3.19	0.02	0	0.02	0.01	4.1	172	5	0.0012	2.9
	I 8, 1943	15.1	9.7	10.8	2.71	0	38.3	63.4	32.3	3.51	0.03	0	0.02	0.04	1.3	180	2.1	0.0008	2.8
	II 15,	14.9	13.4	10.6	3.02	0	46.2	52.5	32.5	2.09	0.03	0	0.03	0.05	2.4	238	2.2	0.0015	2.9
	III 15,	15.4	12.2	10.6	2.99	0	40.0	71.0	25.0	3.62	0.03	0.05	0.04	0.06	1.8	251	2.0	0.0013	2.9
	Mean	**13.2**	**8.8**	**10.9**	**2.22**	**0**	**34.3**	**52.9**	**32.1**	**2.95**	**0.02**	**0.04**	**0.03**	**0.05**	**3.2**	**171.6**	**4.4**	**0.0018**	**3.0**
J	III 15, 1942																		
	V 15,	6.4	2.6	7.4	1.02	2.5	10.1	12.8	16.2			0.03	0.02	0.03	3.3	65	5	0.0026	6.2
	VI 15,	12.0	3.3	9.8	2.22	4.2		14.6	17.9			0.46	0.03	0.16	9.4	107	11	0.0061	5.8
	VII 15,	13.9	4.7	11.3	1.13	6.1	11.7	17.9	21.5			0.05	0.03	0.06	1.5	111	1	0.0016	6.2
	IX 15,	9.3	2.7	10.3	1.18	3.7	9.2	13.6	21.3		0.01	0.12	0.02	0.07	8.3	91	3	0.0040	6.4
	X 15,	10.2	2.5	12.4	1.27	2.6	15.0	18.9	20.4	0.05	0	0.03	0.02	0.05	1.0	94	2	0.0014	6.2
	XI 10,	9.1	2.8	11.0	1.40	3.9	9.0	14.3	17.8	0.04	0	0.11	0.06	0.09	3.4	78	8	0.0022	6.4
	XII 10,	9.2	2.6	10.3	1.13	1.8	10.7	16.8	18.1	0.24	0	0.01	0.02	0.05	2.1	100	3	0.0013	6.1
	I 8, 1943	11.1	4.6	10.6	0.98	5.5	9.9	17.7	17.0	0.09	0.01	0.12	0.02	0.05	1.1	93	2.4	0.0016	6.5
	II 15,	10.1	5.0	11.7	1.33	0.7	14.4	20.2	20.5	0.45	0	0.17	0.03	0.06	1.1	106	1.4	0.0014	4.7
	III 15,	10.0	4.8	9.6	0.94	1.0	10.0	21.0	17.5	0.49	0.01	0.14	0.03	0.06	1.5	104	4.0	0.0024	5.0
	Mean	**10.1**	**3.6**	**10.4**	**1.26**	**3.2**	**11.1**	**16.8**	**18.8**	**0.23**	**0**	**0.12**	**0.03**	**0.07**	**3.3**	**94.9**	**4.1**	**0.0025**	**6.0**

K	III 15, 1942	8.4	2.8	8.3	0.57	5.5	7.4	8.5	17.2			0.07	0.03	0.03	2.9	62	8	0.0043	6.6
	V 15,	7.9	3.6	8.1	0.66	5.4	11.3	7.4	14.2			0.03	0.02	0.03	2.6	65	7	0.0048	6.6
	VII 15,	9.5	2.3	10.6	1.00	6.1		6.4	15.9			0.51	0.01	0.20	25.6	87	403	0.2662	6.5
	VIII 18,	15.0	4.4	16.4	1.31	10.1	17.6	14.6	21.6			0.07	0.03	0.04	2.4	106	2	0.0017	6.8
	IX 15,	13.6	3.7	18.0	1.18	9.2	17.6	14.3	23.0		0	0.03	0.03	0.22	5.0	114	1	0.0027	6.8
	X 15,	12.3	3.1	13.7	1.18	8.1	18.6	10.7	19.6	0.12	0.02	0.01	0.04	0.04	2.3	94	4	0.0020	6.8
	XI 10,	11.7	3.0	10.8	1.38	7.6	14.1	11.3	17.2	0.18	0.01	0.15	0.11	0.08	3.7	85	5	0.0034	6.6
	XII 10,	11.7	2.9	13.8	2.92	6.6	13.4	14.2	15.7	0.21	0.05	0.10	0.13	0.12	8.6	94	12	0.0118	6.5
	I 8, 1943	11.1	4.2	13.1	1.66	7.6	15.0	14.1	18.0	0.22	0.01	0.06	0.03	0.06	3.2	97	3.6	0.0021	6.7
	II 15,	12.5	4.3	14.4	0.92	7.7	17.6	16.5	19.0	0.23	0	0.11	0.03	0.06	3.5	112	6.5	0.0028	6.7
	III 15,	11.9	4.7	13.4	1.88	6.0	16.1	14.5	17.5	0.23	0.01	0.14	0.04	0.07	4.6	101	13.0	0.0057	6.6
	Mean	**11.4**	**3.6**	**12.8**	**1.33**	**7.3**	**14.9**	**12.1**	**18.1**	**0.20**	**0.01**	**0.12**	**0.05**	**0.09**	**5.9**	**9.25**	**42.3**	**0.0280**	**6.7**
L	III 15, 1942	7.8	2.8	9.0	0.90	5.6	6.7	10.6	17.4			0.11	0.02	0.04	2.6	61	9	0.0031	6.0
	V 15,	7.5	3.0	8.5	0.91	4.6	12.9	9.9	15.8			0.03	0.02	0.04	3.4	55	10	0.0053	6.6
	VII 15,	8.9	3.1	10.7	0.75	6.6		9.5	10.4			0.25	0.02	0.38	21.6	72	96	0.0195	6.2
	VIII 15,	11.7	3.5	13.6	1.04	9.2	13.4	13.6	20.4			0.07	0.04	0.09	1.5	97	2	0.0069	6.6
	IX 15,	11.8	2.4	12.1	1.34	5.9	10.7	11.4	18.5		0.01	0.13	0.02	0.07	9.9	91	5	0.0065	6.6
	X 15,	11.2	3.1	13.3	1.29	6.6	14.3	13.6	19.2	0.11	0.01	0.03	0.02	0.05	1.6	96	2	0.0012	6.8
	XI 10,	9.2	3.3	13.1	1.09	6.2	11.2	12.6	16.5	0.22	0.01	0.19	0.03	0.07	2.1	82	8	0.0035	6.6
	XII 10,	9.2	3.4	13.1	1.02	5.2	18.6	14.5	17.4	0.20	0	0.01	0.06	0.06	3.4	95	7	0.0024	6.6
	I 8, 1943	10.3	3.7	11.1	0.87	5.9	12.9	15.6	19.7	0.17	0.01	0.08	0.01	0.05	0.3	84	4.8	0.0017	6.6
	II 15,	11.1	4.6	13.3	0.86	5.5	14.9	18.0	20.0	0.16	0.01	0.18	0.03	0.05	1.4	105	4.0	0.0019	6.6
	Mean	**9.9**	**3.3**	**11.8**	**1.01**	**6.1**	**12.8**	**12.9**	**17.5**	**0.17**	**0.01**	**0.11**	**0.03**	**0.09**	**4.8**	**83.8**	**14.8**	**0.0052**	**6.5**
M	III 15, 1942	7.6	2.3	10.2	0.72	6.1	11.2	8.5	16.8			0.04	0.01	0.03	3.9	63	12	0.0038	6.7
	V 15,	9.1	3.5	13.4	0.82	8.5	16.4	8.2	16.4			0.01	0.03	0.02	2.1	79	3	0.0015	6.9
	VII 15,	7.3	1.7	9.6	0.75	6.0		6.8	12.8			0.20	0.01	0.26	13.6	65	72	0.0280	6.4
	VIII 15,	13.4	3.4	17.3	1.29	11.2	19.1	8.2	14.9			0.24	0.03	0.10	5.4	100	11	0.0032	6.7
	IX 15,	9.3	2.1	13.0	0.97	7.9	11.8	6.8	16.8		0.01	0.05	0	0.07	7.9	86	6	0.0051	7.1
	X 15,	13.3	3.4	16.3	1.04	11.4	18.1	7.9	16.3	0.65	0.02	0.01	0.02	0.10	3.4	97	4	0.0015	7.0
	XI 10,	9.1	2.5	10.5	0.84	7.3	11.6	7.8	15.1	0.06	0.01	0.08	0.03	0.09	3.7	78	19	0.0046	6.8
	XII 10,	9.3	2.9	11.6	0.93	6.9	12.2	8.3	14.6	0.09	0	0.01	0.03	0.05	2.4	84	6	0.0023	6.8
	I 8, 1943	13.5	3.4	11.5	0.91	9.1	14.5	9.0	16.0	0.10	0	0.08	0.03	0.06	0.3	80	2.9	0.0009	6.9
	II 15,	10.6	3.6	15.4	1.09	9.9	18.7	10.6	16.0	0.22	0.01	0.32	0.11	0.07	2.1	96	2.6	0.0017	6.9
	III 15,	10.5	3.7	13.9	0.94	7.2	16.7	11.6	15.5	0.15	0.01	0.03	0.03	0.06	2.2	85	6.0	0.0019	6.9
	Mean	**10.3**	**3.0**	**13.0**	**0.64**	**8.3**	**15.0**	**8.4**	**15.6**	**0.21**	**0.01**	**0.10**	**0.03**	**0.08**	**4.3**	**83.0**	**13.1**	**0.0050**	**6.8**
N	III 15, 1942	7.4	2.8	10.2	0.70	5.2	6.9	9.6	15.4			0.07	0.01	0.04	4.4	56	20	0.0123	6.6
	V 15,	8.8	3.1	10.1	0.88	5.6	11.2	10.3	15.6			0.06	0.02	0.04	3.4	71	4	0.0051	6.7
	VII 15,	9.0	3.5	10.7	0.77	7.5		9.5	12.5			0.18	0.02	0.22	13.0	81	65	0.0207	6.4
	VIII 15,	13.8	5.1	14.5	1.20	11.2	15.1	13.9	19.2			0.08	0.08	0.09	4.7	109	2	0.0013	6.6
	IX 15,	9.8	2.8	9.6	1.43	5.5	11.3	10.4	16.8		0.02	0.18	0.02	0.10	12.5	85	13	0.0144	6.6
	X 15,	11.2	3.6	14.1	1.29	7.7	14.4	13.2	18.7	0.23	0.01	0.03	0.02	0.11	2.3	92	2	0.0021	6.7
	XI 10,	9.1	3.2	10.4	1.15	6.2	11.3	12.6	16.2	0.29	0.01	0.03	0.03	0.08	3.4	85	10	0.0048	6.6
	XII 10,	6.6	1.9	11.1	1.22	3.6	8.2	11.9	12.9	0.13	0.01	0.13	0.02	0.07	6.7	70	37	0.0225	6.4
	I 8, 1943	10.1	4.4	14.0	1.03	7.0	11.6	14.7	19.0	0.40	0.01	0.07	0.03	0.05	2.5	84	9.1	0.0038	6.6
	II 15,	11.3	4.8	14.1	1.16	7.1	14.4	17.8	19.2	0.47	0.01	0.22	0.03	0.06	2.7	99	18.1	0.0099	6.7
	III 15,	10.3	4.6	12.1	1.26	6.3	14.0	16.1	16.0	0.69	0.01	0.26	0.06	0.07	3.0	106	10.0	0.0062	6.7
	Mean	**9.8**	**3.6**	**11.9**	**1.10**	**6.6**	**11.8**	**12.7**	**16.5**	**0.37**	**0.01**	**0.12**	**0.03**	**0.09**	**5.3**	**85.3**	**17.3**	**0.0094**	**6.6**

Table 1. Continued.

Places of sample water taken	Days of sample water taken	CaO mg/l	MgO mg/l	Na_2O mg/l	K_2O mg/l	CO_2 mg/l	SO_3 mg/l	Cl mg/l	SiO_2 mg/l	Fe_2O_3 mg/l	P_2O_5 mg/l	NO_3-N mg/l	NH_4-N mg/l	Albuminoid-N. mg/l	$KMnO_4$ cousumed mg/l	Dissolved residue mg/l	Suspended residue mg/l	Turbidity measured with Pulfrich photometer	pH
O	III 15, 1942	9.8	4.0	9.9	0.59	8.0	5.9	11.0	14.8			0.15	0	0.06	2.9	75	8	0.0050	6.6
	V 15,	10.1	3.8	9.9	0.88	7.7	11.4	10.6	15.4			0.28	0.02	0.07	5.7	70	16	0.0117	6.6
	VII 15,	8.3	2.6	8.0	0.72	7.1		6.1	9.0			0.20	0.01	0.41	14.6	74	81	0.0246	6.3
	VIII 15,	11.0	3.6	10.2	0.72	9.9	36.2	8.9	10.5			0.17	0.11	0.22	14.1	86	31	0.0178	6.5
	IX 15,	10.5	3.6	11.2	0.91	7.7	12.5	8.6	15.0		0.03	0.11	0.02	0.07	8.6	80	1	0.0068	6.5
	X 15,	11.3	4.9	12.3	0.82	11.7	12.5	10.4	18.6	0.35	0.05	0.03	0.02	0.10	2.6	86	6	0.0043	6.8
	XI 10,	10.3	4.3	12.1	0.91	8.3	10.9	11.6	13.1	0.43	0.02	0.26	0.05	0.08	4.1	78	8	0.0046	6.6
	XII 10,	7.6	2.6	10.5	1.04	4.6	6.5	11.7	10.5	0.10	0.01	0.03	0.03	0.07	7.0	69	22	0.0111	6.4
	I 8, 1943	11.2	5.2	11.0	1.29	10.3	9.7	11.6	16.4	0.62	0.02	0.09	0.03	0.06	3.5	74	7.5	0.0046	6.7
	II 15,	10.3	6.0	12.3	0.90	11.1	9.6	13.9	18.0	0.84	0.02	0.16	0.03	0.07	3.3	92	4.3	0.0050	6.7
	III 15,	12.2	6.9	12.4	0.75	9.9	9.5	14.2	15.0	0.95	0.03	0.38	0.06	0.08	2.8	107	5.0	0.0053	6.8
	Mean	**10.2**	**4.3**	**10.9**	**0.87**	**8.8**	**12.5**	**10.8**	**14.2**	**0.55**	**0.03**	**0.17**	**0.04**	**0.12**	**6.3**	**81.0**	**17.3**	**0.0092**	**6.6**
P	III 15, 1942																		
	V 15,	5.6	2.1	4.2	0.91	0.8	10.4	12.4	14.2			0.02	0.05	0.05	5.2	56	5	0.0037	4.6
	VII 15,	9.0	5.8	5.3	1.16	0		30.8	23.5			0.01	0.02	0.09	3.3	108	1	0.0012	3.6
	VIII 15,	8.9	2.2	6.9	1.13	0	15.0	21.4	16.5			0.02	0.05	0.04	0.8	110	3	0.0024	4.4
	IX 15,	7.8	1.8	5.9	0.73	0.9	9.0	13.6	13.3		0	0.04	0.03	0.12	5.4	71	2	0.0024	5.0
	X 15,	8.1	4.3	6.1	0.98	0.9	12.0	17.9	13.1	0.12	0	0.01	0.06	0.09	0.7	72	3	0.0007	4.4
	XI 10,																		
	XII 10,	8.7	2.6	7.3	1.04	0	18.2	32.9	21.1	0.25	0	0.02	0.01	0.04	1.1	123	8	0.0010	4.3
	I 8, 1943	12.8	4.2	6.7	1.31	0	24.3	44.5	26.8	0.54	0.01	0	0.02	0.04	0.3	131	2.3	0.0004	4.1
	II 15,	14.1	5.5	6.6	1.22	0	27.5	57.2	26.0	0.90	0	0	0.03	0.06	1.4	173	1.9	0.0004	3.8
	III 15,	14.8	9.8	7.7	1.63	0	21.0	49.7	21.5	0.41	0.01	0.03	0.03	0.06	1.0	149	1.0	0.0006	3.8
	Mean	**10.0**	**4.3**	**6.3**	**1.12**	**0.3**	**17.2**	**3.12**	**19.6**	**0.44**	**0**	**0.02**	**0.03**	**0.07**	**2.1**	**110.3**	**3.0**	**0.0014**	**4.2**
Q	III 15, 1942																		
	V 15,	4.2	1.7	6.7	0.55	2.5	6.1	8.9	3.6			0.03	0.06	0.05	3.3	40	6	0.0021	6.2
	VII 15,	5.6	1.5	5.8	0.66	1.2		11.9	7.4			0.04	0.04	0.07	1.8	61	0	0.0013	5.8
	VIII 15,	6.6	1.7	6.2	0.81	1.1	9.4	11.8	8.5			0.05	0.04	0.05	2.8	67	5	0.0013	5.4
	IX 15,	7.6	1.7	7.1	0.73	1.1	9.1	12.9	10.3		0	0.05	0.04	0.11	4.7	60	1	0.0025	5.3
	X 15,	7.5	1.2	7.5	0.79	1.1	12.5	12.9	9.4	0.08	0	0.01	0.05	0.08	1.0	65	0	0.0011	5.4
	XI 10,	6.6	1.1	6.9	0.68	0.9	8.9	11.6	11.0	0.06	0	0	0.03	0.06	0.7	49	0	0.0017	5.4
	XII 10,	6.2	1.4	7.4	0.68	0.7	7.2	11.2	10.6	0.04	0	0.01	0.01	0.04	1.1	55	0	0.0016	4.8
	I 8, 1943	10.6	1.1	7.2	0.54	1.5	6.2	10.3	6.0	0.02	0	0	0	0.05	1.9	40	3.7	0.0017	5.3
	II 15,	4.0	1.4	6.7	0.52	1.5	5.2	9.2	3.0	0.01	0	0	0.02	0.04	0.5	36	1.9	0.0014	5.6
	III 15,	4.1	2.3	6.7	0.73	1.8	7.2	8.4	5.0	0.03	0.01	0.03	0.02	0.07	0.5	49	3.0	0.0017	6.1
	Mean	**6.3**	**1.5**	**6.8**	**0.67**	**1.3**	**8.0**	**10.9**	**7.5**	**0.04**	**0**	**0.02**	**0.03**	**0.06**	**1.8**	**52.2**	**2.1**	**0.0016**	**5.5**

R	III 15,1942	15.1	7.5	8.5	1.09	17.1	11.7	5.7	20.2			0.07	0	0.03	2.3	93	2	0.0006	7.2
	V 15,	6.4	2.1	5.3	0.88	1.7	12.1	9.6	15.6			0.06	0.02	0.03	3.6	52	11	0.0051	5.8
	VI 15,	8.3	1.7	6.0	0.86	8.4		5.8	19.1			0.08	0	0.09	2.1	61	2	0.0009	6.8
	VII 15,	13.8	4.3	7.9	1.00	11.8	13.5	6.1	21.9			0.11	0.04	0.05	0.8	87	4	0.0010	7.1
	IX 15,	14.1	4.3	5.9	0.79	10.1	14.1	4.3	18.3		0	0.11	0.01	0.06	3.1	99	2	0.0023	6.8
	X 15,	14.1	4.2	9.3	0.98	11.9	13.9	6.8	20.7	0.05	0	0.01	0.04	0.09	2.0	83	0	0.0009	7.4
	XI 10,	11.1	3.1	7.9	0.93	9.2	8.1	6.5	19.5	0.03	0	0.09	0.03	0.06	2.1	69	3	0.0011	7.0
	XII 10,	9.6	2.3	7.6	1.07	8.3	6.8	6.4	18.2	0.02	0	0	0.03	0.03	0.8	74	3	0.0009	5.8
	I 8,1943	22.7	6.3	7.8	1.08	13.1	13.8	5.8	18.5	0.04	0	0.07	0.02	0.04	0.3	85	3.2	0.0005	6.9
	II 15,	9.0	1.7	7.0	1.18	8.4	4.6	7.0	18.6	0.01	0.01	0.11	0.02	0.06	1.1	67	0.7	0.0010	6.8
	III 15,	16.0	7.6	6.6	0.77	13.5	15.8	5.8	18.0	0.05	0.01	0.13	0.03	0.07	1.3	112	2.0	0.0007	7.0
	Mean	**12.8**	**4.1**	**7.3**	**0.97**	**10.3**	**11.4**	**6.4**	**19.0**	**0.03**	**0**	**0.08**	**0.02**	**0.06**	**1.8**	**80.2**	**3.0**	**0.0041**	**6.8**
S	III 15,1942																		
	V 15,	5.8	1.7	4.8	0.59	1.7	8.5	8.2	11.2			0.04	0.02	0.03	3.3	42	7	0.0033	5.8
	VI 15,	14.7	1.9	6.2	0.86	3.8		8.8	8.8			0.18			2.0	62	0	0.0014	6.4
	VII 15,	8.4	1.6	6.4	0.64	2.2	11.5	10.7	9.1			0.05	0.02	0.05	0.3	69	1	0.0011	6.2
	IX 15,	8.9	2.1	5.7	0.57	4.0	10.4	4.3	11.5		0	0.07	0.04	0.11	5.0	71	2	0.0061	6.4
	X 15,	9.3	2.5	7.0	0.95	2.9	12.9	10.0	10.8	0.01	0	0.01	0.01	0	0	70	1	0.0007	6.4
	XI 10,	10.0	2.4	5.9	0.61	5.8	11.2	7.2	12.9	0.05	0	0.10	0.03	0.06	2.0	58	1	0.0010	6.6
	XII 50,	6.6	1.6	7.0	0.68	1.8	8.6	9.7	10.3	0.05	0	0·02	0.02	0.03	1.0	62	2	0.0019	6.2
	I 8,1943	7.7	2.0	6.9	0.62	3.3	7.5	9.6	10.1	0.02	0	0	0	0.05	2.1	48	2.5	0.0011	5.9
	II 15,	5.9	1.8	7.3	0.55	2.6	7.1	8.8	5.5	0.01	0	0.10	0.02	0.05	0.9	53	2.3	0.0013	6.3
	III 15,	6.0	1.7	7.4	0.54	2.6	6.4	8.1	6.5	0.01	0.01	0.03	0.02	0.05	0.3	53	1.0	0.0009	6.2
	Mean	**8.3**	**1.9**	**6.5**	**0.66**	**3.1**	**9.3**	**8.5**	**9.7**	**0.03**	**0**	**0.06**	**0.02**	**0.05**	**1.7**	**58.8**	**2.0**	**0.0019**	**6.2**
T	III 15,1942	3.8	1.8	5.3	0.61	4.3	0.9	6.7	8.8			0.11	0.01	0.06	2.4	32	4	0.0015	6.4
	V 15,	6.4	1.8	6.1	0.81	4.4	5.3	6.7	10.2			0.03	0.05	0.04	2.6	34	2	0.0011	6.4
	VI 15,	6.0	2.1	6.4	0.63	5.6		6.4	11.7			0.10	0.10	0.17	3.4	50	2	0.0015	6.3
	VII 15,	7.7	1.1	7.1	0.81	6.6	9.6	7.1	19.3			0.07	0.04	0.09	1.8	56	4	0.0008	6.4
	IX 15,	6.2	1.3	5.7	0.57	5.5	4.9	4.3	12.3		0	0.11	0.02	0.07	7.3	58	4	0.0028	6.5
	X 15,	6.9	2.0	6.5	0.72	6.2	6.7	6.4	12.4	0.07	0	0.03	0.02	0.04	2.9	67	2	0.0007	6.5
	XI 10,	6.1	1.5	6.8	0.77	5.5	4.3	6.8	12.7	0.07	0	0.11	0.04	0.06	2.8	49	3	0.0020	6.4
	XII 10,	6.6	1.3	7.6	0.64	4.2	5.4	6.9	12.0	0.05	0	0	0.02	0.06	1.8	52	4	0.0008	6.4
	I 8,1943	5.0	2.5	7.7	0.52	4.4	3.9	5.8	12.5	0.05	0	0	0	0.04	0.6	47	2.5	0.0007	6.5
	II 15,	6.0	2.3	7.2	0.52	4.9	6.6	8.1	11.0	0.11	0	0	0.03	0.05	1.3	59	2.1	0.0006	6.3
	III 15,	7.0	2.5	9.7	0.91	4.9	6.0	9.0	9.5	0.07	0	0.15	0.09	0.05	1.8	64	4.0	0.0019	6.4
	Mean	**6.2**	**1.8**	**6.6**	**0.63**	**5.1**	**5.4**	**6.8**	**12.0**	**0.07**	**0**	**0.07**	**0.04**	**0.07**	**2.6**	**51.6**	**3.1**	**0.0013**	**9.4**
U	III 15,1942	6.1	2.4	6.1	0.59	4.8	4.6	7.1	9.6			0.11	0.03	0.04	2.6	44	1	0.0026	6.5
	V 15,	6.6	1.9	5.4	0.55	2.3	8.9	8.9	11.4			0.05	0	0.02	2.8	47	3	0.0039	6.2
	VI 15,	7.7	2.7	6.3	0.71	4.6		8.1	11.0			0.13	0.01	0.06	2.6	68	6	0.0012	6.4
	VII 15,	9.0	2.8	7.4	0.81	3.7	9.7	10.4	11.8			0.07	0.01	0.06	1.1	72	1	0.0021	6.4
	IX 15,	8.5	2.1	6.4	0.68	4.4	7.9	7.1	13.5		0	0.08	0.02	0.05	3.1	61	1	0.0036	6.7
	X 15,	9.4	2.5	5.8	0.75	4.2	11.2	9.3	13.5	0.01	0	0.03	0.02	0	0	68	1	0.0004	6.6
	XI 10,	8.2	2.0	7.4	0.68	5.5	8.8	8.2	13.5	0.05	0	0.11	0.03	0.06	1.6	50	2	0.0009	6.6
	XII 10,	7.3	1.9	7.0	0.68	2.9	8.0	9.0	11.6	0.02	0	0.02	0.02	0.01	1.1	64	4	0.0017	6.4
	I 10,1943	8.5	2.4	7.7	0.61	4.0	7.0	9.8	16.5	0	0	0	0.02	0.05	0.8	56	0.5	0.0006	6.0
	II 15,	6.7	2.8	6.3	0.47	3.5	9.8	10.9	12.0	0	0	0	0.03	0.05	0.8	62	1.2	0.0006	6.1
	III 15,	7.0	3.0	7.1	0.63	2.9	6.8	9.7	10.0	0	0	0.05	0.02	0.04	0.1	64	1.0	0.0005	6.3
	Mean	**7.7**	**2.4**	**6.6**	**0.65**	**3.9**	**8.3**	**9.0**	**12.2**	**0.01**	**0**	**0.06**	**0.02**	**0.04**	**1.5**	**59.6**	**2.0**	**0.0016**	**6.4**

Table 1. Continued.

Places of sample water taken	Days of sample water taken	CaO mg/l	MgO mg/l	Na_2O mg/l	K_2O mg/l	CO_2 mg/l	SO_3 mg/l	Cl mg/l	SiO_2 mg/l	Fe_2O_3 mg/l	P_2O_5 mg/l	NO_3-N mg/l	NH_4-N mg/l	Albuminoid-N mg/l	$KMnO_4$ consumed mg/l	Dissolved residue mg/l	Suspended residue mg/l	Turbidity measured with Pulfrich photometer	pH
V	IV 15, 1942	5.7	2.6	9.5	0.81	4.7	4.7	7.4	14.2			0.07	0.04	0.06	3.7	70	10	0.0057	6.5
	V 15,	7.7	2.6	7.2	0.79	3·7	9.7	9.6	13.4			0.07	0.01	0.05	3.7	60	5	0.0054	6.5
	VI 15,	10.7	3.5	8.7	0.86	5.9		8.1	11.0			0.12	0.01	0.19	9.7	68	36	0.0120	6.3
	VIII 15,	9.8	3.0	9.4	0.75	6.1	12.4	10.7	13.8			0.05	0.03	0.07	1.8	77	5	0.0019	6.6
	IX 15,	9.2	2.5	9.5	1.00	5.3	10.7	8.9	15.0		0.01	0.13	0.02	0.07	9.6	77	10	0.0104	6.6
	X 19,	10.1	3.5	10.9	1.02	7.5	13.0	12.1	17.3	0.29	0.01	0.01	0.03	0.09	3.9	80	3	0.0021	6.9
	XI 10,	8.0	2.8	11.8	1.02	5.1	7.6	11.9	16.9	0.19	0	0.15	0.04	0.07	3.7	72	10	0.0036	6.5
	XII 19,	10.1	3.3	9.2	0.91	5.0	9.1	12.0	16.4	0.12	0	0.01	0.03	0.04	1.6	74	8	0.0057	6.5
	I 8, 1943	8.4	3.3	10.5	0.64	5.2	8.1	11.9	14.9	0.17	0.01	0	0.02	0.05	4.7	70	6.4	0.0025	6.5
	II 15,	8.2	3.8	10.3	0.93	5.3	11.1	13.2	14.0	0.20	0	0.11	0.04	0.06	1.7	74	5.5	0.0026	6.4
	III 15,	9.0	4.2	12.8	1.32	5.5	8.6	14.8	13.5	0.29	0.01	0.13	0.06	0.06	2.2	85	5.0	0.0032	6.6
	Mean	**8.8**	**3.2**	**10.0**	**0.91**	**5.4**	**9.5**	**11.0**	**14.6**	**0.21**	**0.01**	**0.08**	**0.03**	**0.07**	**4.2**	**73.4**	**9.5**	**0.0050**	**6.5**
W	IV 15, 1942	6.4	2.6	8.8	0.81	5.0	5.9	9.6	12.6			0.12	0.05	0.07	3.9	57	20	0.0120	6.6
	V 15,	7.8	2.7	8.3	0.86	4.2	10.6	10.3	13.6			0.04	0.06	0.04	3.7	54	11	0.0082	6.6
	VI 15,	7.5	2.5	9.4	0.84	6.0		9.5	13.7			0.13	0.01	0.11	8.1	76	17	0.0078	6.5
	VIII 15,	9.7	3.0	10.1	0.91	6.8	10.6	10.7	13.7			0.03	0.05	0.06	1.5	76	5	0.0041	6.8
	IX 15,	10.0	3.2	11.9	1.32	6.1	12.3	10.7	18·0		0.01	0.07	0.02	0.10	10.9	86	4	0.0059	6.7
	X 15,	10.1	3.4	10.8	1.20	7.0	12.6	11.8	16.6	0.21	0	0.01	0.04	0.06	3.1	89	4	0.0015	6.8
	XI 10,	8.4	3.2	10.3	1.16	5.5	9.8	11.6	15.9	0.22	0.01	0.15	0.09	0.07	2.4	78	20	0.0062	6.7
	XII 10,	9.1	2.7	10.5	0.97	5.1	10.7	11.5	11.0	0.25	0	0.03	0.05	0.05	2.4	76	8	0.0037	6.6
	I 8, 1943	10.1	3.1	10.5	0.85	5.3	8.9	12.5	16.0	0.21	0.01	0.06	0.01	0.04	4.4	70	4.0	0.0028	6.6
	II 15,	8.5	3.9	11.2	0.98	5.3	10.3	13.2	14.5	0.24	0.01	0.06	0.02	0.05	1.7	75	6.4	0.0040	6.6
	III 15,	8.5	4.5	13.3	0.90	5.5	9.9	14.5	16.0	0.44	0	0.12	0.03	0.06	1.8	95	6.0	0.0037	6.7
	Mean	**8.7**	**3.2**	**10.5**	**0.93**	**5.6**	**10.2**	**11.5**	**14.7**	**0.31**	**0.01**	**0.08**	**0.04**	**0.07**	**4.0**	**75.6**	**9.6**	**0.0054**	**6.7**
X	VI 15, 1942	6.8	2.5	10.1	1.20	5.3		9.5	16.1			0.10	0.02	0.10	7.5	72	7	0.0041	6.6
	VIII 15,	10.3	4.8	15.5	1.75	6.3	15.8	16.4	22.9			0.05	0.03	0.22	1.4	95	5	0.0015	6.7
	IX 15,	6.5	2.8	10.7	1.27	5.1	9.4	10.0	17.5		0	0.05	0	0.07	5.4	76	2	0.0035	6.8
	X 15,	7.1	3.0	10.5	1.20	5.1	9.3	11.8	16.6	0.09	0	0.02	0.03	0.09	3.3	80	4	0.0022	6.6
	XI 10,	6.6	3.1	12.4	1.22	5.5	10.3	11.9	17.7	0.12	0	0.03	0.03	0.06	3.1	82	5	0.0019	6.6
	XII 11,	5.7	2.3	12.9	1.45	3.4	9.8	12.9	15.7	0.08	0.01	0.01	0	0.07	7.6	82	31	0.0150	6.4
	I 8, 1943	6.7	4.6	15.3	1.28	5.9	9.3	14.7	19.0	0.19	0.01	0	0.02	0.06	2.8	79	4.1	0.0022	6.6
	II 15,	8.2	5.1	15.7	1.32	6.2	12.2	9.9	17.5	0.25	0.01	0.10	0.17	0.06	3.6	89	3.4	0.0023	6.7
	III 15,	8.1	5.9	16.8	1.42	4.8	9.1	17.7	16.0	0.41	0.01	0.13	0.06	0·11	3.5	98	9.0	0.0048	6.7
	IV 15,	8.4	3.7	11.5	1.12	3.8	7.5	13.7	14.8	0.09	0	0.10	0.02	0.05	2.7	74	10	0.0038	6.7
	V 15,	3.8	3.6	10.3	0.61	3.1	2.8	8.5	10.0	0.05	0.01	0.03	0.01	0.07	4.1	54	13	0.0054	6.5
	VI 15,	5.2	3.2	8.2	0.96	3.5	6.5	8.9	12.5	0.18	0.01	0.03	0.02	0.06	2.2	61	3	0.0027	6.5
	Mean	**7.0**	**3.7**	**12.5**	**1.23**	**4.8**	**9.3**	**12.2**	**16.4**	**0.16**	**0.01**	**0.06**	**0.03**	**0.09**	**3.9**	**78.5**	**8.0**	**0.0041**	**6.6**

Y	III 15,1942	4.2	2.1	16.2	1.40	4.5	2.3	17.9	23.4			0.07	0.11	0.13	13·1	86	51	0.0170	6.4
	V 15,	5.7	2.1	12.4	1.00	5.0	7.1	14.2	15.2			0.02	0.02	0.06	7.3	63	20	0.0069	6.4
	VII 15,	7.0	1.6	11.9	1.11	5.9		12.9	12.9			0.15	0	0.17	8.6	80	19	0.0078	6.4
	VIII 15,	8.3	3.2	10.9	1.07	7.7	6.5	10.7	10.9			0.18	0.01	0.09	3.4	77	10	0.0080	6.6
	IX 15,	14.6	3.3	9.8	2.33	13.2	4.6	10.7	12.5		0.23	0.40	0.04	0.28	18.0	91	10	0.0098	6.4
	X 15,	7.6	1.9	14.6	1.81	6.6	8.3	15.7	17.8	0.12	0.04	0.15	0.03	0.19	10.7	85	38	0.0034	6.4
	XI 10,	14.9	4.3	18.8	1.95	15.2	8.4	23.9	14.6	4.53	0.23	0.27	0.45	0.34	19.3	136	39	0.0204	6.4
	XII 10,	5.3	2.3	23.9	2.91	4.4	7.6	30.4	22.3	0.08	0.04	0.02	0.18	0.19	9.9	103	9	0.0131	6.4
	I 8,1943	19.1	3.7	19.7	2.22	8.6	6.0	21.9	19.5	1.32	0.06	0.02	0.12	0.08	1.9	91	4.6	0.0034	6.4
	II 15,	10.1	2.9	27.0	3.98	.11.5	9.3	24.6	20.0	0.50	0.12	1.97	0.86	0.17	8.7	118	6.7	0.0036	6.5
	III 15,	6.0	3.4	22.9	2.68	5.4	6.2	22.3	22.5	0.58	0.06	0.28	0.20	0.11	4.6	115	14.0	0.0094	6.4
	Mean	**9.4**	**2.8**	**17.1**	**2.04**	**8.0**	**6.6**	**18.7**	**17.4**	**1.19**	**0.11**	**0.32**	**0.18**	**0.17**	**9.6**	**95.0**	**20.1**	**0.0093**	**6.4**
Z	III 15,1942	11.5	3.8	9.1	0.70	6.2	10.7	9.6	11.8			0.15	0	0.02	3.3	74	5	0.0034	6.6
	V 15,	9.3	3.7	8.6	0.70	5.4	17.7	9.9	12.6			0.23	0.02	0.07	5.4	75	14	0.0102	6.6
	VI 15,	4.4	2.0	6.1	0.50	6.0		5.4	7.6			0.17	0.02	0.16	13.0	54	33	0.0110	6.0
	VIII 15,	10.9	3.8	10.6	0.50	9.6	12.3	8.9	13.4			0.15	0.03	0.11	6.7	83	20	0.0019	6.4
	IX 15,	10.4	3.9	9.1	0.68	5.7	15.7	7.5	12.0		0.04	0.10	0.02	0.12	7.9	92	4	0.0057	6.2
	X 15,	11.0	4.3	9.2	0.75	8.1	15.0	8.9	15.7	0.65	0.05	0.01	0.04	0.06	2.1	83	6	0.0036	6.8
	XI 10,	10.2	3.9	9.6	0.79	5.8	13.3	10.2	12.8	0.20	0.01	0.24	0.10	0.07	4.4	83	14	0.0032	6.4
	XII 14,	12.3	4.3	11.6	0.71	5.2	13.3	13.1	14.0	0.16	0	0.02	0.02	0.06	2.9	76	27.0	0.0231	6.5
	I 8,1943	9.9	4.5	9.8	0.65	7.3	12.6	9.2	15.0	0.27	0.01	0.02	0.02	0.06	0.9	72	3.7	0.0032	6.7
	II 15,	10.3	5.7	10.4	0.42	7.5	14.2	11.0	15.5	0.31	0.01	0.14	0.05	0.12	2.2	84	4.2	0.0031	6.7
	III 15,	11.9	6.0	9.9	0.94	7.1	13.5	11.6	12.5	0.46	0.01	0.27	0.04	0.07	2.7	94	13.0	0.0061	6.7
	Mean	**10.2**	**4.2**	**9.5**	**0.67**	**6.7**	**13.8**	**9.6**	**13.0**	**0.33**	**0.02**	**0.14**	**0.03**	**0.08**	**4.7**	**79.1**	**13.1**	**0.0068**	**6.5**

Table 2. The stream volumes on the days of sample water taken. (cubic metres per second.)

Names of river systems.	Names of rivers.	Places of observation carried.	Gathering areas. (sq. kirometres)	April 15, 1942	May 15, 1942	July 15, 1942	August 15, 1942	September 15, 1942	October 15, 1942	November 15, 1942	December 15, 1942
Yoneshiro	Yoneshiro	Akabuchi, Miyakawa-mura, Kazuno-gun.	545.0	39.61	26.16	19.77	5.00	31.72	10.04	15.99	18.46
Yoneshiro	Oyu	Oyu, Oyu-cho, Kazuno-gun.	162 0	13 60	8.53	7.25	5.30	13.12	7.89	7.58	7.58
Yoneshiro	Koani	Yagizawa, Kamikoani-mura, Kitaakita-gun.	92.5	20 20	15.30	6.61	2.24	6.23	3.48	4.28	3.48
Omono	Minase	Katsurazawa, Minase-mura, Okatsu-gun.	100.0	10.80	6.54	15.60	1.16	2.76	2.76	3.90	2.61
Omono	Naruse	Tekura, Honnaruse-mura, Okatsu-gun.	137.0	18 40	10.20	8.20	2 44	5.26	2.98	6.22	5.26
Omono	Tama	Tazawa, Tazawa-mura, Senboku-gun.	333.0	41.90	39.70	17.50	7.33	27.90	9.17	14.20	10.70
Koyoshi	Koyoshi	Motomachi, Yajima-cho, Yuri-gun.	345 0	178.00	27.20	4.58	2.01	30.60	24.20	58.50	14 30

Table 3. Composition of Dissolved Inorganic Components.

	Ca %	Mg %	Na %	K %	NH_4 %	CO_3 %	SO_4 %	Cl %	NO_3 %	PO_4 %	SiO_2 %	Fe_2O_3 %	Total %	Salinity parts per million
A	10.74	3.00	8.12	0.87	0.05	9.21	30.62	9.01	.058	0.01	27·49	0.30	100.00	77.0
B	7.50	1.87	9.22	0.89	0.04	12.11	18.02	9.18	0.29	0.02	40.80	0.06	100.00	85.5
C	13.15	3.20	5.92	0.76	0.04	4.68	44.96	6.35	0.45	0	20.06	0.43	100.00	136.3
D	9.26	2.84	7.97	1.58	0.07	6.04	36.46	8.27	0.85	0.04	26.08	0.54	100.00	96.0
E	9.60	3.20	9.68	1.10	0.05	7.88	30.23	10.51	0.81	0.01	26.64	0·29	100.00	86.3
F	10.09	3.63	12.03	1.17	0.05	17.74	13.01	16.33	0.19	0	25.70	0.06	100.00	61.8
G	10.33	3.39	11.51	1.35	0.04	16.63	16.55	15.91	0.22	0.01	24.02	0.04	100.00	75.8
H	9.94	3.11	10.24	1.21	0.05	10.72	24.36	13.08	0.54	0	36.48	0.27	100.00	75.5
I	6.11	3.45	5.23	1.20	0.02	0	26.71	34.37	0.12	0.02	20.85	1.92	100.00	153.8
J	10.01	2.97	10.72	1.45	0.06	6.03	18.43	23.21	0.76	0.01	26.03	0.32	100.00	72.3
K	10.26	2.69	11.92	1.39	0.08	12.44	22.43	15.15	0.64	0.02	22.73	0.25	100.00	79.5
L	9.59	2.69	11.89	1.14	0.04	11.37	20.96	17.59	0.65	0.01	23.84	0.23	100.00	73.5
M	9.98	2.42	13.07	1.06	0.05	15.42	24.50	11.46	0.58	0.02	21.15	0.29	100.00	73.6
N	9.65	3.01	12.21	1.26	0.06	12.50	19.64	17.60	0.73	0.02	22.81	0.51	100.00	72.3
O	10.17	3.63	11.22	1.00	0.07	16.57	20.78	14.07	1.04	0.05	19.74	0.76	100.00	72.0
P	8.14	2.93	5.33	1.06	0.05	0.46	23.53	35.57	0.09	0	22.34	0.50	100.00	87.6
Q	10.97	2.22	12.34	1.37	0.10	4.46	23.36	26.60	0.24	0	18.24	0.10	100.00	41.0
R	12.78	3.47	7.55	1.12	0.04	19.74	19.26	8.91	0.48	0.01	26.60	0.04	100.00	71.3
S	12883	2.50	10.33	1.19	0.06	9.03	24.17	18.41	0.58	0	20.84	0.06	100.00	46.4
T	10.04	2.53	11.70	1.30	0.11	15.99	14.66	15.39	0.66	0	27.46	0.16	100.00	43.9
U	11.24	2.95	10.02	1.10	0.04	10.79	20.20	18.23	0.53	0	24.88	0.02	100.00	49.1
V	10.28	3.13	12.08	1.24	0.07	12.00	18.61	17.89	0.55	0.01	23.80	0.34	100.00	61.3
W	9.85	3.01	12.24	1.29	0.08	12.08	19.22	18.05	0.52	0.01	23.16	0.49	100.00	63.4
X	7.74	3.49	14.44	1.60	0.07	10.26	17.33	18.93	0.40	0.01	25.48	0.25	100.00	64.2
Y	8.28	2.09	15.73	2.11	0.30	13.52	9.86	23.11	1.76	0.18	21.59	1.47	100.00	80.7
Z	10.92	3.78	10.51	0.83	0.06	13.74	24.88	14.36	0.90	0.04	19.48	0.60	100.00	66.7
*	20.39	3.41	5.79	2.12		35.15	12.14	5·68	0.90		11.67	2.75**	100.00	

* Clarke's general average of water in the world. ** $(Fe, Al)_2O_3$

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