CHEMICAL INVESTIGATION ON RIVER WATERS OF SOUTHEASTERN ASIATIC COUNTRIES (Report I.)
THE QUALITY OF WATERS OF THAILAND

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I. INTRODUCTION

The quality of water has much to do not only with our daily life but also with various enterprises such as agriculture, industry, fishery etc.

The difference in the amount of chemical constituents dissolved in waters is important problems when it comes to rationalization of fertilization, planning of irrigation works etc. particularly in Asiatic countries where rice-growing is the core of the agriculture and the rivers are the main sources of irrigation water.

I made chemical investigations on rivers throughout the whole territory of Japan during the past many years since 1941 and revealed the nature of waters in these rivers. This time I had the opportunity to reveal the quality of waters in southeastern Asiatic countries where the weather, geological conditions etc. differ greatly from those prevailing in Japan thanks to the aid extended by the Rockefeller Foundation and the cooperations rendered by the governments of respective countries.

Here I report the analytical results conducted in my laboratory for the purpose of obtaining general outlook on the nature of water in Thailand, a country internationally known as a great rice exporter.

With the aid of concerned circles including Royal Highness Lak Kashemsanta, Director of the Agricultural Bureau of Thailand, 28 rivers, 2 lakes and 1 city water were chosen and sample waters were taken simultaneously 12 times once in each month for the duration of one year from respective places. These samples were sent by air to my laboratory. This report is the fruit of the investigation thus conducted.

II. SAMPLING

(a) *Selection of places where samples were collected.*

I went to Bangkok in June, 1956 and after consulting with Royal Highness Lak Kashemsanta, Director of the Agricultural Bureau, selected 31 places covering the whole territory of Thailand. The details are shown in Table 1 and Fig. 1. These places include 11 places within the Mae Nam Chao Phraya basin (commonly known as the Mae Nam River in Japan) which is the principal rice producing area in Thailand as well as 3 places in the main stream of the Mae Khong River flowing along the frontier line between Thailand and Laos, 6 places in the tributaries of the same river, rivers and lake in the Malay peninsula, city water of Bangkok etc.

(b) *Method of Sampling.*

Sampling of water was made using polyethylene containers previously sent by me at a point 15—20 cm below the surface of the water at a middle place of a river where the water current is fastest and the depth is greatest, with the cooperation of agricultural technicians stationed near the respective sampling places.

After being accumulated without losing any time at the office of Director of the Agricultural Bureau mentioned above, they were sent to my laboratory by air parcel.

(c) *Time of Sampling.*

Sampling at 30 places except service water of Bangkok city was made simultaneously on July 15, 1956 for the first time and then simultaneous sampling was repeated on the 15th of each month 12 times during the period of full one year ending on June 15, 1957.

However, there were some cases in which the sampling dates were altered due to transportation facilities or conveniences on the part of the sampler. In view of the circumstances sampling dates are mentioned respectively in the analytical results in Table 2.

Table 1. Places of sampling.

No.	Name of river.	Places of sampling.
1	Mae Khong R.	Chiengsan, Chiengrai.
2	Mae Khong R.	Thakai, Nongkai Province.
3	Mae Khong R.	Mukdaharn Village, Mukdaharn District, Nakorn Panom Province.
4	Lake Nong Han	Middle of Nong Han, far from Don Sawan Island to the east about 300 meters, Sakon Nakhon.
5	Chi R.	Bankai Local Amphur Muang, Changwad Chaiyaphum.
6	Chi R.	Tha Phra Village, Kon Khen.
7	Phao R.	Kalasin.
8	Mun R.	Tumbol Toom, Amphur Tartoom, Surin.
9	Mun R.	Tumbol Phatum Amphur Muang, Changwad Ubolrajatani.
10	Chantaburi R.	North of the Bridge-Tacheng, Chantaburi.
11	Prachin R.	Prachinbury Market, Muang District.
12	Bang Pakong R.	Namuang Amphur Muang Chachoengsao.
13	Ping R.	Chedi Ngarm, outside USIS, Chiengmai.
14	Wang R.	Banlang Village, Amphur Muang Lampang.
15	Ping R.	Rahang District, Amphur Muang Changwad Tak.
16	Nan R.	Changwad Nan.
17	Nan R.	Pitsanuloke.
18	Yom R.	Klongtan Village, Srisamrong, Sukhothai.
19	Mae Nam Chao Phraya (Salaklang R.)	In front of the Salaklang Changwad, Uthai Thani.
20	Mae Nam Chao Phraya	Sompowlome Village, Amphur Krungkow, Ayuthaya.
21	Pa Sak R.	Petchabun.
22	Pa Sak R.	Sriburi Rak Temple, Pakpreow Village, Muang District, Saraburi Province.
23	Mae Nam Chao Phraya	Tumbol Parkred Amphur Parkred Changwad Nonburi.
24	Supan R.	Tapiliang District, Supanburi.
25	Kwae Noi R.	Wang Po, Siyoak Subdistrict, Kanchanaburi.
26	Mae Klong R.	Burgpai Amphur Bang Pong of Rajburi.
27	Chumphon R. (Tatapao R.)	Near the railway bridge, Chumphon.
28	Tapi R.	Suratthani.
29	Lake Talesaab	Between the islands Kohyai and Kohhaa, Lumpum Village, Patthalung.
30	Sai Buri R.	Tah Ruah District, Tumbol Rusoh Amphur Rusoh Changwad Narathiwat.
31	Service Water of Bangkok City	Embassy of Japan, Saladaeng Lane, Silom Road, Bangkok.

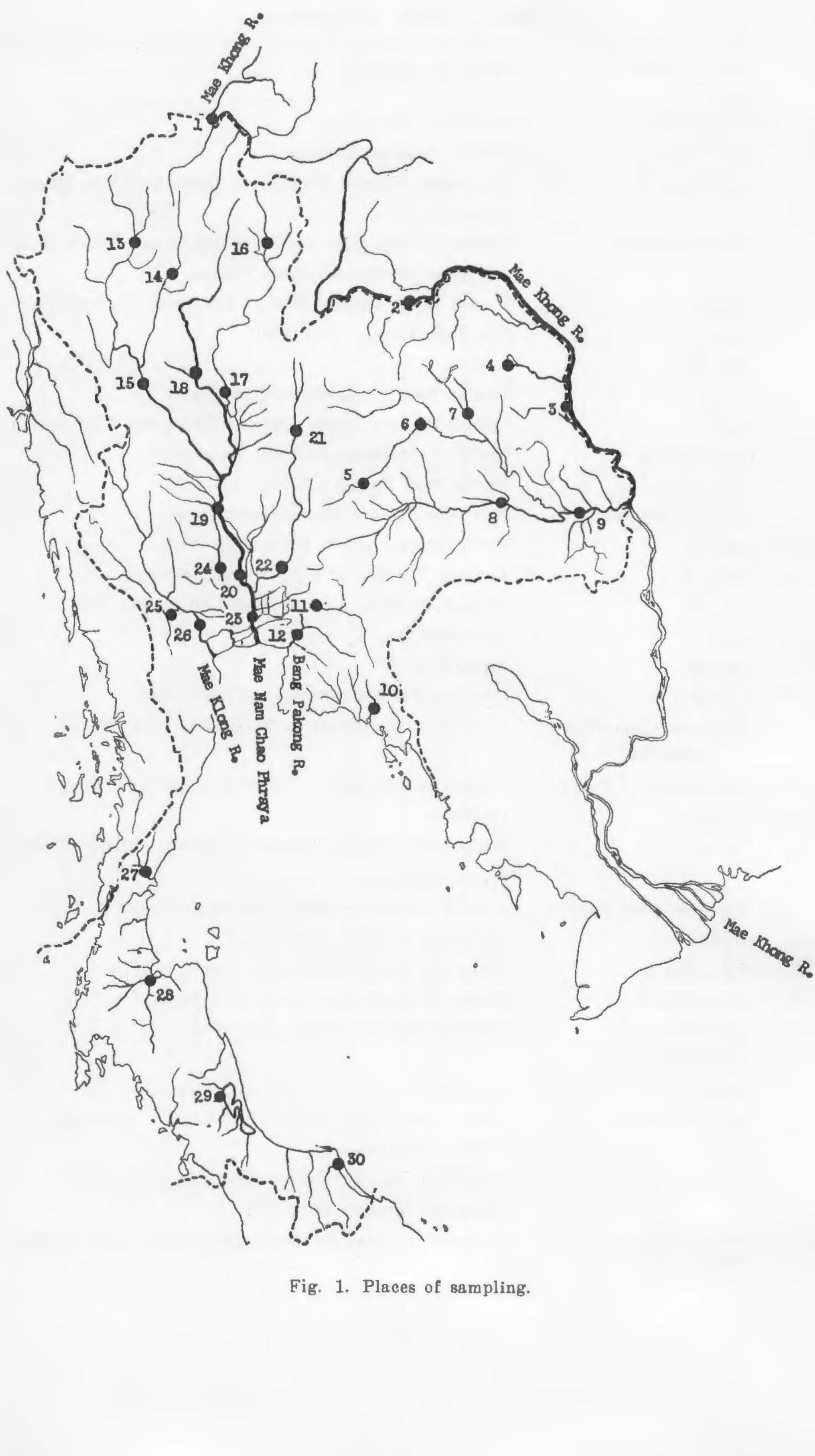


Fig. 1. Places of sampling.

Table 2. Analytical results (ppm). * Turbidity of 1 ppm of Kaoline is one unit. ** Expressed in $CaCO_3$ ppm.

Name of river	Places of sampling	Date of collection	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Fe	PO_4	NO_3-N	NH_4-N	Albuminoid-N	$KMnO_4$ consumed	Dissolved solids	Suspended solids	Turbidity*	pH	Hardness**	Note
Mae Khong River	Chiengsan	1956. 7.15	42.2	4.6	5.9	1.8	143.4	15.2	4.2	14.1	0.00	0.00	0.04	0.03	0.31	9.8	156	—	388.8	7.2	124.2	
		8.15	21.7	3.9	4.2	1.3	82.9	8.4	1.3	15.5	0.01	0.00	0.00	0.02	0.17	22.8	98	359.3	209.2	6.8	70.4	
		9.15	25.7	4.1	4.9	1.3	98.4	8.3	3.1	14.6	0.01	0.00	0.00	0.00	0.04	12.2	110	219.5	128.0	6.7	80.4	
		10.15	29.6	6.4	7.2	1.5	115.1	15.7	5.5	13.1	0.00	0.11	0.03	0.05	0.02	2.4	135	113.0	63.2	6.8	100.2	
		11.15	27.8	5.7	7.4	1.8	107.3	12.1	5.5	13.8	0.00	0.00	0.01	0.05	0.01	11.4	127	131.5	67.9	6.9	93.0	
		12.15	30.7	3.7	8.9	1.9	117.0	17.8	7.3	14.6	0.00	0.00	0.01	0.01	0.00	5.2	146	80.0	57.4	7.0	92.0	
		1957. 1.16	32.4	7.2	9.1	1.7	120.1	15.1	7.8	17.9	0.01	0.00	0.00	0.05	0.03	7.1	151	76.7	47.9	7.2	110.8	
		2.15	33.3	7.5	10.8	1.6	122.3	17.8	8.1	14.6	0.01	0.00	0.00	0.06	0.14	3.4	152	70.4	21.6	6.8	114.2	
		3.16	34.4	7.8	11.4	1.7	125.6	24.5	9.7	16.5	0.00	0.01	0.00	0.06	0.05	1.7	168	26.6	8.3	7.1	118.1	
		4.15	36.3	7.8	11.8	2.4	127.3	28.6	11.4	14.6	0.00	0.00	0.00	0.03	0.10	2.6	177	122.2	106.3	6.6	122.9	
		5.15	36.2	6.9	13.1	2.0	121.5	30.1	14.0	11.7	0.00	0.00	0.06	0.05	0.11	2.9	182	330.3	214.8	6.7	118.8	
		6.15	34.5	5.4	6.0	1.7	122.3	11.6	5.0	11.6	0.00	0.00	0.04	0.03	0.02	4.2	142	519.2	428.0	7.0	108.5	
		Average	**32.1**	**5.9**	**8.4**	**1.7**	**116.9**	**17.1**	**6.9**	**14.4**	**0.00**	**0.01**	**0.02**	**0.04**	**0.08**	**7.1**	**145.3**	**186.2**	**145.1**	**6.9**	**104.5**	
Mae Khong River	Nongkai	1956. 7.15	30.9	3.9	5.7	1.9	110.6	9.0	3.9	14.7	0.00	0.00	0.09	0.03	0.28	5.1	124	—	335.1	6.9	93.2	
		8.15	23.7	3.2	3.3	1.2	89.6	4.8	2.6	16.0	0.00	0.00	0.00	0.05	0.23	40.4	100	470.0	379.3	6.8	72.2	
		9.15	22.8	4.1	4.2	1.9	92.1	6.0	3.0	14.6	0.00	0.00	0.00	0.00	0.00	8.7	100	301.6	128.5	6.7	73.8	
		10.15	28.9	5.2	5.6	1.2	112.9	10.0	3.0	13.9	0.01	0.00	0.02	0.04	0.01	5.4	124	151.5	189.3	6.9	93.7	
		11.15	29.2	5.6	6.7	1.2	112.6	12.5	4.3	13.8	0.00	0.00	0.01	0.06	0.02	8.7	128	85.9	126.6	7.0	95.9	
		12.15	31.2	6.3	7.6	1.2	118.7	15.1	5.8	14.6	0.00	0.00	0.01	0.05	0.01	4.0	143	82.4	88.0	7.2	103.9	
		1957. 1.15	32.8	6.9	8.5	1.3	122.8	16.8	7.8	17.5	0.01	0.00	0.10	0.03	0.20	9.0	149	44.5	46.4	7.0	110.5	
		2.15	34.4	6.8	9.8	1.2	124.5	18.2	5.6	16.0	0.00	0.01	0.00	0.05	0.03	1.2	154	35.9	4.6	7.1	113.9	
		3.15	33.8	7.2	10.9	1.6	127.3	20.2	9.1	15.3	0.00	0.00	0.00	0.09	0.11	1.9	160	24.0	12.3	7.0	114.2	
		4.15	37.0	6.9	11.6	1.6	134.2	25.0	10.2	15.9	0.00	0.00	0.00	0.01	0.03	1.1	177	68.5	18.7	7.0	121.0	
		5.15	34.8	6.3	11.4	2.2	120.9	24.5	11.8	13.3	0.00	0.00	0.14	0.03	0.09	2.9	164	90.9	119.4	6.9	113.0	
		6.15	33.7	5.4	7.0	2.2	121.7	13.8	6.8	14.0	0.00	0.00	0.09	0.06	0.07	4.1	147	558.9	166.3	6.8	106.4	
		Average	**31.1**	**5.7**	**7.7**	**1.6**	**115.6**	**14.7**	**6.2**	**15.0**	**0.00**	**0.00**	**0.04**	**0.04**	**0.09**	**7.7**	**139.2**	**174.1**	**134.5**	**6.9**	**101.0**	
Mae Khong River	Mukdaharn	1956. 7.15	17.9	2.8	3.6	1.3	66.0	3.7	2.5	12.9	0.00	0.00	0.05	0.02	0.17	7.1	81	—	137.6	6.7	56.0	
		8.15	18.9	2.4	2.7	1.1	71.5	2.4	0.7	13.4	0.00	0.00	0.03	0.05	0.33	20.0	80	241.2	107.8	6.6	57.2	
		10.15	23.6	3.5	5.0	1.2	92.1	7.6	2.9	12.4	0.01	0.01	0.02	0.02	0.01	3.5	105	154.2	95.1	6.8	73.3	
		11.15	26.6	4.2	6.1	1.1	102.9	10.4	4.5	13.6	0.00	0.00	0.01	0.03	0.01	4.9	116	119.5	136.5	6.9	83.8	
		12.15	29.0	5.7	7.6	1.2	111.2	12.5	3.4	14.6	0.00	0.02	0.01	0.03	0.01	4.9	129	63.6	61.8	7.2	96.0	
		1957. 1.15	30.2	6.0	8.6	1.2	114.8	15.0	7.8	17.2	0.00	0.00	0.00	0.02	0.03	6.4	137	46.3	12.6	7.0	100.3	
		2.15	31.2	6.3	10.0	1.3	117.0	16.0	9.1	15.1	0.00	0.00	0.00	0.04	0.03	1.1	147	29.8	2.3	7.1	104.1	
		3.15	31.9	6.6	10.6	1.3	119.2	19.9	9.9	15.3	0.01	0.00	0.00	0.05	0.06	1.5	152	16.8	13.0	7.1	106.9	
		4.15	32.4	6.3	10.3	1.8	119.2	17.5	10.0	14.8	0.00	0.00	0.00	0.08	0.07	1.4	155	21.9	21.3	6.9	106.9	
		5.15	33.7	6.6	12.0	1.9	116.7	21.8	13.4	13.6	0.00	0.00	0.33	0.03	0.30	1.9	164	20.7	5.8	7.0	111.4	
		6.15	19.9	3.6	6.5	1.5	73.2	7.4	8.4	9.2	0.00	0.00	0.01	0.06	0.04	3.5	101	285.0	34.5	6.8	64.5	
		Average	**26.8**	**4.9**	**7.5**	**1.4**	**100.3**	**12.2**	**6.6**	**13.8**	**0.00**	**0.00**	**0.04**	**0.04**	**0.10**	**5.1**	**124.3**	**99.9**	**57.1**	**6.9**	**87.3**	

Name of river	Places of sampl-ing	Date of collection	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Fe	PO_4	NO_3-N	NH_4-N	Albumi-noid-N	$KMnO_4$ consum-ed	Dissolv-ed solids	Suspend-ed solids	Turbi-dity*	pH	Hard-ness**	Note
Lake Nong Han	Sakon Nakhon	1956. 7.15	2.7	0.4	5.7	1.9	12.8	0.5	9.3	5.5	0.37	0.00	0.53	0.03	0.18	9.9	51	—	216.9	6.0	8.3	
		8.15	3.1	0.5	4.2	1.5	13.9	0.7	7.2	6.0	0.08	0.00	0.00	0.12	0.18	21.3	58	36.8	41.6	6.2	9.8	
		10.15	4.6	1.0	4.2	1.1	21.1	0.0	5.7	6.5	0.00	0.00	0.01	0.05	0.02	13.7	48	12.7	8.3	6.2	15.6	
		11.15	3.6	1.0	4.5	1.0	18.6	0.5	6.4	6.3	0.01	0.00	0.00	0.02	0.00	5.3	40	19.0	7.8	6.3	13.3	
		12.15	3.0	1.0	4.7	1.0	16.9	0.0	7.9	5.2	0.04	0.00	0.01	0.02	0.01	5.8	41	28.8	6.1	6.2	11.5	
		1957. 1.15	2.6	0.9	5.5	0.9	15.8	0.0	9.1	5.0	0.01	0.00	0.00	0.04	0.01	8.8	40	11.6	11.3	6.2	10.1	
		2.15	2.8	0.8	6.2	1.1	14.7	0.0	9.7	5.3	0.10	0.00	0.02	0.05	0.05	2.4	51	17.2	23.1	6.2	10.4	
		3.15	2.9	0.7	6.6	1.2	14.7	0.0	11.3	5.7	0.12	0.00	0.00	0.08	0.11	3.0	55	30.3	32.2	6.1	10.1	
		4.15	2.7	0.6	7.0	1.5	15.3	0.2	12.6	6.4	0.10	0.00	0.01	0.04	0.10	2.8	58	52.6	39.4	6.0	9.3	
		5.15	2.7	0.4	8.4	2.1	14.1	1.0	13.7	5.6	0.15	0.00	0.03	0.02	0.43	3.1	59	39.1	127.0	6.2	8.5	
		6.15	2.5	0.4	6.3	2.5	12.5	0.5	11.7	11.8	0.33	0.00	0.03	0.05	0.05	2.8	61	107.5	128.8	6.0	7.7	
		Average	3.0	0.7	5.8	1.4	15.5	0.3	9.5	6.3	0.12	0.00	0.06	0.05	0.10	7.2	51.1	35.6	58.4	6.1	10.4	
Chi River	Chaiyaphum	1956. 7.15	11.1	1.4	9.9	3.0	39.1	1.2	15.9	10.6	0.09	0.00	0.32	0.03	0.20	12.8	87	—	104.0	6.3	33.8	
		8.15	9.6	1.1	1.5	1.5	36.3	1.2	0.0	10.3	0.05	0.00	0.00	0.07	0.05	47.4	58	71.9	41.0	6.3	28.6	
		10.15	15.2	2.1	3.5	1.7	59.9	0.0	2.1	11.4	0.01	0.00	0.02	0.05	0.01	—	75	55.2	19.8	6.6	46.7	
		11.15	19.7	2.9	12.8	1.7	67.1	5.8	21.0	12.9	0.01	0.00	0.00	0.04	0.00	6.9	113	44.2	23.6	6.6	61.0	
		12.15	33.4	4.3	17.4	2.0	114.5	13.6	27.0	12.6	0.00	0.00	0.06	0.02	0.01	4.9	164	46.7	10.9	6.9	101.4	
		1957. 1.15	45.0	6.6	36.8	3.3	145.6	16.3	47.5	14.0	0.00	0.00	0.25	0.02	0.24	14.9	240	85.9	40.4	6.9	139.6	
		2.15	48.7	8.1	38.3	4.5	164.7	18.8	46.3	10.3	0.00	0.00	0.00	0.04	0.08	2.2	253	65.8	3.4	7.1	155.0	
		3.18	17.2	2.1	12.2	4.1	61.3	8.2	1.6	9.5	0.08	0.01	0.04	0.04	1.06	6.0	80	750.0	862.4	6.4	51.5	
		4.15	18.7	0.5	8.2	4.1	66.3	3.1	9.1	13.5	0.01	0.64	0.42	0.12	0.04	2.2	100	159.7	52.2	6.3	48.7	
		5.15	12.3	1.6	12.7	4.6	43.8	0.0	14.4	9.5	0.04	0.01	0.49	0.04	0.09	4.3	82	265.2	285.1	6.3	37.1	
		6.15	11.4	1.2	2.0	2.7	45.5	1.6	0.0	9.3	0.05	0.00	0.26	0.05	0.43	3.9	74	170.0	147.1	6.3	33.5	
		Average	22.0	2.9	14.1	3.0	76.7	6.3	16.8	11.3	0.03	0.06	0.17	0.05	0.20	10.6	120.5	171.5	144.5	6.5	67.0	
Chi River	Kon Khen	1956. 7.15	7.3	0.7	11.6	3.7	28.0	1.0	18.7	7.8	0.54	0.00	0.27	0.03	0.36	16.5	99	—	373.4	6.3	21.2	
		8.15	12.5	1.4	20.5	3.0	42.7	1.7	32.3	12.1	0.27	0.00	0.14	0.06	0.31	23.5	135	150.4	272.2	6.4	36.9	
		10.15	11.1	1.7	9.2	1.8	46.6	0.0	11.9	10.5	0.03	0.01	0.01	0.04	0.01	—	79	60.7	33.1	6.5	35.0	
		11.15	16.6	2.8	25.1	1.9	57.7	2.9	40.0	12.2	0.00	0.00	0.07	0.06	0.01	5.7	134	36.1	17.8	6.6	52.8	
		12.15	25.2	4.1	56.3	2.7	77.6	5.8	95.8	11.9	0.00	0.01	0.12	0.01	0.00	6.4	246	18.9	32.3	6.9	79.7	
		1957. 1.15	30.2	6.6	86.8	3.5	94.0	11.6	143.0	6.2	0.01	0.00	0.02	0.06	0.00	7.6	335	16.5	6.8	7.2	102.8	
		2.15	40.7	8.4	137.8	5.0	111.7	12.1	235.1	5.1	0.01	0.01	0.00	0.04	0.01	2.8	521	11.3	4.0	7.2	136.3	
		3.15	40.7	10.0	192.9	6.2	115.1	14.3	312.5	8.1	0.00	0.00	0.02	0.05	0.04	3.0	651	19.8	3.6	6.9	142.5	
		4.15	17.2	2.4	14.0	3.8	62.7	0.5	24.1	12.7	0.01	0.00	0.00	0.02	0.06	2.5	114	74.2	36.6	6.6	52.8	
		5.15	17.9	4.3	70.0	5.8	78.8	4.7	121.1	14.2	0.00	0.00	0.00	0.05	0.06	3.0	298	33.5	3.1	6.8	62.7	
		6.15	12.2	1.4	3.9	5.0	52.1	3.0	4.7	9.8	0.09	0.00	0.20	0.04	0.03	4.0	80	183.1	198.0	6.5	36.5	
		Average	21.1	4.0	57.1	3.9	69.7	5.2	94.5	10.1	0.09	0.00	0.08	0.04	0.08	7.5	244.7	60.5	89.2	6.7	69.0	

Phao River	Kalasin	1956. 7.20	6.0	1.0	6.1	4.4	30.2	3.4	7.3	11.0	0.08	0.00	0.64	0.04	0.28	16.5	71	—	304.9	6.1	19.0
		8.20	5.9	0.5	3.5	2.4	25.5	0.8	3.0	8.7	0.20	0.00	0.00	0.08	0.14	19.4	49	70.8	128.7	6.2	16.8
		9.20	6.8	1.0	6.2	1.8	28.0	0.0	8.7	11.0	0.15	0.00	0.00	0.21	0.21	11.5	69	24.7	44.3	6.2	21.2
		10.20	9.4	2.2	11.5	2.4	45.5	0.0	16.4	10.4	0.01	0.00	0.09	0.02	0.02	10.8	81	100.0	157.3	6.2	32.3
		11.20	9.1	2.4	24.7	2.3	51.9	0.0	33.4	17.3	0.00	0.00	0.01	0.03	0.02	6.0	120	6.4	4.4	6.5	32.8
		12.18	9.6	2.5	28.3	2.4	51.0	0.0	43.9	17.6	0.01	0.01	0.04	0.03	0.01	6.1	131	146.7	26.6	6.6	34.5
		1957. 1.21	10.4	2.7	32.6	3.5	56.6	0.0	49.8	20.7	0.01	0.00	0.00	0.05	0.03	11.4	145	44.6	38.5	6.7	37.0
		2.20	10.9	2.9	37.7	3.9	55.2	0.0	56.3	20.2	0.00	0.00	0.00	0.03	0.15	2.8	159	24.8	9.7	6.5	39.0
		3.21	11.4	3.0	39.8	4.9	59.3	0.0	60.9	19.1	0.02	0.00	0.28	0.12	0.09	2.7	166	36.9	11.1	6.5	41.0
		4.20	12.5	3.2	41.8	6.1	64.1	0.0	64.1	22.1	0.01	0.00	0.03	0.08	0.05	2.2	179	26.6	10.0	6.7	44.4
		5.20	11.6	3.3	41.3	7.3	61.6	0.0	63.5	22.3	0.00	0.00	0.03	0.05	0.06	3.8	185	37.9	17.8	6.4	42.5
		6.21	4.1	0.5	10.1	8.5	21.6	0.0	18.8	8.3	0.16	0.02	0.44	0.07	0.22	5.1	77	488.6	790.7	5.9	12.3
		Average	9.0	2.1	23.6	4.2	45.9	0.3	35.5	15.7	0.05	0.00	0.13	0.07	0.11	8.2	119.3	91.6	128.7	6.4	31.1
Mun River	Surin	1956, 7.18	4.4	0.4	17.7	2.8	17.7	3.0	27.3	9.7	0.59	0.00	0.56	0.03	0.49	20.8	123	—	240.4	6.1	12.5
		8.20	7.4	0.6	15.8	2.4	29.7	0.7	23.1	13.9	0.57	0.00	0.00	0.07	0.10	18.8	99	69.8	172.9	6.2	20.9
		10.16	5.7	1.0	17.5	1.2	23.6	0.0	25.0	11.0	0.12	0.01	0.02	0.11	0.22	8.1	101	15.2	34.2	6.3	18.2
		11.15	27.6	0.5	13.5	0.9	37.4	0.8	47.2	12.3	0.19	0.00	0.07	0.12	0.28	14.1	154	63.3	113.1	6.6	71.1
		12.20	12.3	2.3	46.6	1.6	41.3	0.4	109.1	13.1	0.08	0.00	0.01	0.02	0.13	7.3	207	36.1	20.5	6.6	40.1
		1957. 1.17	7.9	1.3	7.1	2.2	17.5	0.0	21.9	14.3	0.06	0.00	0.10	0.56	0.24	14.8	76	101.3	15.5	5.9	24.8
		2.20	18.6	4.3	164.3	3.0	45.5	3.8	261.0	15.8	0.01	0.00	0.04	0.12	0.17	3.4	509	29.0	7.5	6.7	64.3
		3.20	8.7	1.7	9.8	5.8	10.3	0.1	32.2	14.3	0.03	0.03	0.69	0.50	0.53	4.0	87	151.6	13.9	5.9	29.0
		4.20	5.3	0.4	7.6	3.7	3.1	1.9	24.4	10.8	0.97	0.00	0.25	0.25	0.38	3.4	84	428.7	540.8	5.0	14.7
		5.17	12.9	0.6	7.9	4.8	5.0	1.2	25.7	13.7	0.27	0.01	2.37	0.12	0.09	4.2	102	248.7	294.4	4.9	34.6
		6.19	5.4	0.3	7.8	4.4	6.7	2.5	25.5	11.9	0.83	0.01	0.71	0.21	0.23	5.3	91	163.6	557.8	5.2	14.8
		Average	10.6	1.2	28.7	3.0	21.6	1.3	56.6	12.8	0.34	0.01	0.44	0.19	0.26	9.5	148.5	130.7	182.8	5.9	31.4
Mun River	Ubolrajatani	1956. 7.15	2.6	0.2	5.9	2.8	13.3	3.2	8.8	7.8	0.65	0.00	0.62	0.03	0.48	17.5	71	—	524.5	6.0	7.1
		8.15	4.4	0.3	8.4	2.3	18.9	2.3	11.3	9.1	0.23	0.00	0.00	0.04	0.03	12.0	68	95.3	177.3	5.9	12.1
		9.15	4.4	0.3	4.5	1.6	18.0	0.0	5.2	7.3	0.33	0.01	0.00	0.00	0.00	9.1	55	64.6	80.1	6.1	12.3
		10.15	6.9	1.4	9.1	1.5	31.3	0.1	11.6	9.1	0.00	0.00	0.02	0.04	0.01	6.1	65	11.1	18.0	6.3	23.3
		11.19	8.7	1.6	18.0	1.4	37.7	0.4	26.5	12.2	0.12	0.00	0.08	0.07	0.00	8.9	100	26.4	40.1	6.5	27.2
		12.17	11.3	2.4	28.7	1.6	44.4	0.5	45.7	11.1	0.01	0.00	0.00	0.03	0.00	8.0	131	55.4	16.8	6.5	37.9
		1957. 1.16	14.1	3.0	59.6	2.1	50.7	3.4	91.6	12.2	0.00	0.00	0.02	0.02	0.06	9.6	212	32.7	7.1	6.8	47.6
		2.18	13.7	3.6	76.0	2.3	46.0	2.3	124.4	11.3	0.00	0.00	0.00	0.02	0.04	2.4	264	15.4	4.0	6.9	49.0
		3.16	12.8	3.5	86.8	3.0	47.1	1.3	126.3	10.2	0.00	0.00	0.01	0.14	0.33	3.1	285	25.9	13.5	6.5	46.3
		4.16	19.5	4.7	66.8	4.5	74.3	6.5	105.3	10.9	0.01	0.00	0.10	0.07	0.15	2.8	264	19.3	29.0	6.8	68.1
		5.15	14.9	3.4	55.0	4.6	60.7	1.3	84.3	13.8	0.01	0.00	0.12	0.06	0.05	3.5	216	32.5	8.6	6.6	51.2
		6.15	17.9	3.6	61.1	6.4	66.0	2.4	98.4	14.3	0.01	0.00	0.23	0.17	0.28	3.7	251	134.3	48.4	6.5	59.7
		Average	10.9	2.3	40.0	2.8	42.4	2.0	61.6	10.8	0.11	0.00	0.10	0.06	0.12	7.2	165.2	46.6	80.6	6.4	36.8

Name of river	Places of sampling	Date of collection	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Fe	PO_4	NO_3-N	NH_4-N	Albuminoid-N	$KMnO_4$ consumed	Dissolved solids	Suspended solids	Turbidity*	pH	Hardness**	Note
Chantaburi River	Chantaburi	1956. 7.15	1.6	0.5	2.3	1.0	13.3	0.1	0.9	16.7	0.08	0.00	0.33	0.09	0.14	4.8	31	—	15.8	6.2	6.0	
		8.15	1.6	0.7	2.4	0.7	14.7	1.2	1.2	16.4	0.01	0.00	0.07	0.14	0.00	5.3	34	20.4	7.0	6.2	6.8	
		9.16	1.7	0.6	1.7	0.9	11.4	0.0	0.6	11.9	0.01	0.00	0.07	0.01	0.01	5.5	27	76.0	12.2	6.0	6.8	
		10.15	1.6	0.6	2.4	0.7	14.4	1.3	1.1	13.1	0.04	0.01	0.08	0.05	0.01	3.7	31	39.1	11.7	6.2	6.6	
		11.15	1.6	0.2	0.9	2.6	6.1	2.3	0.6	11.6	0.08	0.01	0.38	0.06	0.02	11.7	32	81.9	387.6	5.0	4.8	
		12.15	2.6	0.8	3.0	1.1	19.4	0.0	1.9	16.7	0.04	0.00	0.01	0.02	0.00	5.4	40	5.4	4.0	6.3	9.8	
		1957. 1.15	2.3	0.7	3.3	1.2	20.5	0.0	1.9	17.9	0.04	0.00	0.02	0.07	0.04	—	42	8.7	9.7	6.4	8.7	
		2.15	2.4	0.9	5.9	2.2	19.1	0.0	5.9	13.1	0.00	0.01	0.00	0.10	0.05	—	44	17.7	2.3	5.8	9.3	
		3.15	2.1	0.7	3.9	1.6	20.5	0.4	3.2	14.6	0.04	0.00	0.11	0.13	0.08	2.6	37	15.6	6.2	6.3	9.1	
		4.15	1.9	0.7	3.1	1.7	18.6	0.6	1.6	16.8	0.00	0.00	0.06	0.07	0.05	2.4	41	9.1	10.1	6.3	7.4	
		5.15	1.9	0.7	3.3	1.7	17.7	0.0	1.5	17.8	0.01	0.00	0.32	0.06	0.07	2.7	41	10.0	7.5	6.2	7.6	
		6.15	2.0	0.7	2.7	1.0	16.1	1.8	1.7	14.8	0.11	0.01	0.12	0.03	0.01	2.5	38	22.4	7.5	6.1	8.0	
		Average	**1.9**	**0.7**	**2.9**	**1.4**	**16.0**	**0.6**	**1.8**	**15.6**	**0.04**	**0.00**	**0.13**	**0.07**	**0.04**	**4.7**	**36.5**	**27.8**	**40.1**	**6.1**	**7.6**	
Prachin River	Prachinbury	1956. 7.15	2.3	0.5	1.8	1.0	13.3	2.0	0.7	8.2	0.15	0.00	0.48	0.03	0.18	8.8	33	—	81.9	6.0	7.9	
		8.15	2.9	0.6	1.6	0.8	14.7	0.0	0.3	8.3	0.03	0.00	0.01	0.13	0.14	9.7	31	40.6	43.0	6.0	9.8	
		10.15	6.5	1.7	2.2	0.8	33.0	1.4	1.2	9.4	0.03	0.00	0.02	0.05	0.01	6.1	45	32.6	27.4	6.5	23.2	
		11.15	8.1	2.5	4.9	0.8	41.3	3.6	3.6	11.6	0.04	0.00	0.02	0.03	0.00	3.7	60	26.8	22.5	6.6	30.3	
		12.15	8.1	2.8	5.9	1.0	41.9	3.0	5.2	11.0	0.03	0.00	0.04	0.02	0.01	7.8	68	42.6	19.5	6.5	31.8	
		1957. 1.15	9.9	4.2	9.8	1.4	50.7	5.3	11.1	13.6	0.05	0.00	0.12	0.18	0.26	16.6	85	53.3	43.5	6.5	42.2	
		2.15	12.6	4.4	13.1	2.0	61.3	8.0	15.9	14.3	0.08	0.00	0.21	0.09	0.05	2.8	110	76.2	24.2	6.7	49.5	
		3.15	13.4	4.8	14.9	2.3	68.2	10.0	19.4	15.1	0.05	0.00	0.24	0.10	0.23	3.3	114	132.8	40.8	6.5	53.4	
		4.15	12.4	6.9	15.3	3.5	59.1	11.8	19.4	16.4	0.06	0.00	0.17	0.08	0.10	2.8	120	23.9	114.2	6.5	59.2	
		5.15	11.0	3.6	16.5	1.8	55.5	9.1	20.5	17.7	0.03	0.00	0.26	0.06	0.11	3.9	120	163.0	118.8	6.6	42.4	
		6.15	5.5	1.4	6.9	3.8	25.8	8.2	8.4	11.6	0.10	0.00	0.39	0.17	0.04	3.3	73	156.6	225.2	6.2	19.7	
		Average	**8.4**	**3.0**	**8.4**	**1.7**	**42.3**	**5.7**	**9.6**	**12.5**	**0.06**	**0.00**	**0.18**	**0.09**	**0.10**	**6.3**	**78.1**	**74.8**	**69.2**	**6.4**	**33.6**	
Bang Pakong River	Chachoengsao	1956. 7.16	2.8	0.8	4.1	1.8	10.3	12.7	3.7	9.3	0.22	0.00	0.36	0.03	0.20	11.4	61	—	215.5	5.8	10.4	
		8.15	2.9	0.8	3.3	1.0	13.9	5.8	3.0	9.9	0.07	0.00	0.00	0.15	0.08	15.6	50	59.3	63.4	5.8	10.8	
		10.16	3.8	1.7	5.3	0.9	20.0	5.8	4.8	8.0	0.03	0.00	0.02	0.16	0.16	5.2	49	67.2	22.1	6.0	16.4	
		11.15	3.6	1.5	7.0	1.5	19.1	11.8	7.2	10.4	0.33	0.01	0.10	0.08	0.18	4.7	56	40.8	66.2	6.2	15.3	
		12.19	4.1	1.6	12.1	2.5	25.0	12.4	14.7	14.7	0.38	0.01	0.02	0.09	0.22	14.1	84	178.8	233.0	6.4	16.8	
		1957. 1.17	—	—	—	—	—	—	240.9	—	—	—	—	—	—	—	—	—	—	—	—	Sea water mixed
		2.16	—	—	—	—	—	—	3827.8	—	—	—	—	—	—	—	—	—	—	—	—	
		3.19	—	—	—	—	—	—	5099.1	—	—	—	—	—	—	—	—	—	—	—	—	
		4.16	—	—	—	—	—	—	3685.4	—	—	—	—	—	—	—	—	—	—	—	—	
		5.16	—	—	—	—	—	—	2953.2	—	—	—	—	—	—	—	—	—	—	—	—	
		6.	—	—	—	—	—	—	729.6	—	—	—	—	—	—	—	—	—	—	—	—	
		Average	**3.4**	**1.3**	**6.4**	**1.5**	**17.7**	**9.7**	***** 6.7**	**10.5**	**0.21**	**0.00**	**0.10**	**0.10**	**0.17**	**10.2**	**60.0**	**86.5**	**120.0**	**6.0**	**13.9**	

*** Calculated without the samples sea water mixed.

Ping River	Chingmai	1956. 7.15	23.9	3.7	4.6	3.5	105.1	0.0	0.0	28.2	0.01	0.00	0.24	0.03	0.16	8.4	108	—	32.1	6.6	75.2
		8.15	8.0	1.0	2.0	2.6	35.2	1.1	0.3	14.6	0.04	0.01	0.01	0.05	0.65	3.7	53	519.1	587.4	6.1	24.0
		9.15	20.8	3.9	2.6	2.1	88.5	0.0	0.1	19.9	0.02	0.00	0.00	0.00	0.12	22.0	89	194.4	201.6	6.8	67.8
		10.15	23.7	3.7	3.2	2.1	103.4	0.5	0.0	17.5	0.00	0.00	0.02	0.02	0.01	8.3	103	89.1	39.3	6.8	74.4
		11.15	24.2	3.6	3.3	2.1	104.8	0.4	0.0	19.0	0.00	0.00	0.00	0.10	0.02	5.3	105	22.8	7.0	6.8	75.1
		12.15	25.2	4.1	4.7	2.5	108.4	1.1	1.6	22.8	0.01	0.00	0.03	0.07	0.04	9.4	118	38.7	12.7	6.6	79.9
		1957. 1.15	24.7	4.5	4.2	2.3	108.1	0.4	0.6	27.0	0.00	0.00	0.01	0.21	0.09	8.2	113	13.9	13.0	6.8	80.1
		2.15	25.5	4.3	4.6	2.4	109.5	0.7	0.6	28.4	0.00	0.00	0.00	0.03	0.01	1.5	119	28.5	7.5	6.9	81.6
		3.15	27.4	4.3	5.2	3.3	120.1	0.7	1.9	28.1	0.02	0.00	0.52	0.03	0.08	2.6	129	32.4	19.8	6.9	86.4
		4.15	32.1	4.0	4.4	3.0	135.9	0.8	0.0	28.8	0.00	0.00	0.00	0.07	0.07	1.1	141	17.5	9.9	7.1	96.5
		5.15	24.2	4.7	5.0	2.9	113.1	1.2	0.8	26.5	0.00	0.00	0.00	0.02	0.24	2.1	122	41.3	6.1	6.6	79.9
		6.15	17.9	3.9	3.5	3.4	93.4	1.8	0.0	22.5	0.00	0.02	0.14	0.07	0.05	3.3	103	136.2	30.8	6.6	60.5
		Average	23.1	3.8	3.9	2.7	102.1	0.7	0.5	23.6	0.01	0.00	0.08	0.06	0.13	6.3	108.6	103.1	80.6	6.7	73.5
Wang River	Lampang	1956. 7.15	29.0	4.0	4.5	3.3	116.7	2.4	0.0	23.1	0.00	0.00	0.06	0.04	0.12	6.3	120	—	375.4	6.9	89.1
		8.15	17.4	2.2	2.2	3.5	70.4	4.1	0.0	14.8	0.03	0.00	0.00	0.02	0.75	22.7	83	1616.8	2849.8	6.4	52.7
		9.15	32.9	4.5	4.2	2.2	130.9	3.7	0.8	20.3	0.03	0.00	0.00	0.00	0.16	18.4	137	262.7	314.3	7.0	100.9
		10.15	34.0	3.9	4.5	2.2	135.6	2.6	0.0	17.6	0.00	0.01	0.02	0.09	0.12	3.8	136	41.7	8.5	7.0	101.1
		11.15	27.9	3.7	4.2	2.2	114.8	3.7	0.9	18.5	0.00	0.00	0.00	0.06	0.07	2.2	118	8.9	3.3	7.0	84.9
		12.15	28.7	3.7	4.7	2.3	116.2	0.0	0.4	20.6	0.00	0.00	0.00	0.01	0.08	2.8	124	13.0	5.1	7.0	87.0
		1957. 1.15	30.1	6.0	10.5	9.0	115.9	0.0	3.1	27.1	0.00	0.00	0.20	0.09	0.29	12.7	166	97.8	6.5	7.0	100.0
		2.15	26.2	4.5	6.1	3.1	109.0	1.2	1.3	24.1	0.00	0.00	0.00	0.02	0.05	2.4	119	18.4	5.0	7.0	83.9
		3.15	27.9	3.5	6.2	3.4	120.1	1.3	2.5	25.8	0.01	0.00	0.00	0.08	0.24	1.4	129	57.3	1.5	7.0	84.0
		4.15	27.5	3.9	5.7	4.6	119.2	0.0	0.6	26.3	0.00	0.00	0.00	0.05	0.04	2.1	126	26.5	12.1	6.9	84.6
		5.15	32.7	4.6	5.6	4.0	136.4	0.0	0.0	24.7	0.02	0.00	0.00	0.02	0.08	—	143	284.9	339.1	7.0	100.6
		6.15	25.8	4.0	4.2	3.6	113.1	1.6	0.0	21.4	0.00	0.01	0.02	0.07	0.01	1.9	108	89.6	9.4	6.8	80.8
		Average	28.3	4.0	5.2	3.6	119.0	1.7	0.8	22.0	0.01	0.00	0.02	0.05	0.17	7.0	125.8	228.9	327.5	6.9	87.5
Ping River	Tak	1956. 7.16	20.7	3.1	5.4	3.7	91.2	0.2	0.0	24.3	0.00	0.00	0.06	0.04	0.26	10.5	103	—	102.4	6.6	64.4
		8.15	19.9	2.8	3.9	2.6	84.0	0.0	0.9	19.5	0.01	0.00	0.26	0.01	0.35	39.7	95	214.5	333.8	6.5	61.3
		9.15	18.2	2.7	3.3	2.6	79.9	0.1	0.0	19.0	0.02	0.00	0.00	0.00	0.16	31.7	87	140.3	254.4	6.6	56.5
		10.15	20.7	3.0	4.7	2.3	93.7	0.2	0.0	15.9	0.00	0.00	0.03	0.05	0.10	11.8	93	354.2	283.3	6.6	64.2
		11.15	23.3	3.5	4.4	2.3	100.1	0.7	0.0	17.4	0.00	0.02	0.00	0.01	0.00	7.7	100	80.4	40.8	7.0	72.6
		12.15	24.7	3.6	4.9	2.6	107.6	0.0	1.6	19.4	0.00	0.00	0.02	0.05	0.01	5.4	108	33.7	26.6	6.7	76.2
		1957. 1.15	22.2	3.3	5.0	2.8	110.9	0.0	0.6	24.2	0.01	0.00	0.05	0.04	0.06	6.0	126	25.2	7.4	6.7	68.7
		2.15	27.3	3.7	4.9	2.8	117.6	0.0	0.6	22.7	0.00	0.00	0.00	0.02	0.02	1.5	119	21.0	2.6	6.8	83.6
		3.15	29.5	4.8	5.7	3.2	128.9	0.0	1.7	22.8	0.00	0.00	0.00	0.05	0.06	1.6	133	30.3	6.3	6.8	93.6
		4.15	29.2	4.2	6.3	4.2	126.2	0.5	1.9	22.1	0.00	0.00	0.01	0.09	0.04	1.9	130	45.8	18.3	6.8	90.2
		5.15	31.2	4.5	6.6	5.1	136.7	0.0	1.1	25.6	0.00	0.00	0.06	0.05	0.17	3.8	144	51.4	35.3	6.7	96.2
		6.15	18.7	2.7	4.1	4.2	81.2	1.6	0.0	21.4	0.00	0.00	0.00	0.05	0.03	3.5	96	412.8	37.0	6.5	57.7
		Average	23.8	3.5	4.9	3.2	104.8	0.3	0.7	21.2	0.00	0.00	0.04	0.04	0.10	10.4	111.2	128.1	95.7	6.7	73.7

Name of river	Places of sampling	Date of collection	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Fe	PO_4	NO_3-N	NH_4-N	Albuminoid-N	$KMnO_4$ consumed	Dissolved solids	Suspended solids	Turbidity*	pH	Hardness**	Note
Nan River	Nan	1956. 7.15	23.9	2.9	4.2	1.1	94.8	1.9	0.0	22.0	0.01	0.00	0.15	0.04	0.13	4.3	98	—	36.0	6.8	71.5	
		8.15	16.2	1.5	2.7	1.4	61.0	0.0	0.8	16.1	0.02	0.01	0.00	0.01	0.55	60.2	69	946.1	2113.3	6.5	46.5	
		9.15	23.7	2.4	3.6	0.9	82.1	0.0	0.6	21.6	0.01	0.00	0.00	0.03	0.27	7.4	90	266.1	154.0	6.7	69.2	
		10.15	24.9	3.3	5.6	0.9	106.5	0.0	0.9	18.8	0.00	0.00	0.02	0.02	0.01	1.9	107	39.4	7.3	6.8	75.7	
		11.15	27.8	3.6	5.9	0.7	116.5	0.7	0.9	19.4	0.00	0.00	0.01	0.06	0.00	1.9	117	12.4	2.1	7.0	84.3	
		12.15	27.9	4.1	6.1	0.7	118.1	0.0	1.6	18.9	0.01	0.00	0.01	0.03	0.00	5.5	121	4.8	2.3	7.0	86.7	
		1957. 1.15	30.7	4.2	6.9	0.9	125.3	0.0	1.7	21.4	0.00	0.00	0.01	0.10	0.05	9.0	128	4.9	3.0	7.2	93.9	
		2.15	30.1	4.2	7.1	0.9	124.5	1.2	2.0	20.0	0.00	0.00	0.01	0.08	0.02	2.2	129	3.2	3.0	7.2	92.5	
		3.15	27.2	4.5	7.3	1.3	118.1	0.0	3.1	21.3	0.02	0.01	0.00	0.10	0.22	3.3	130	7.8	0.0	7.1	86.2	
		4.15	26.2	3.9	7.5	1.3	119.8	0.0	3.1	22.5	0.00	0.00	0.00	0.03	0.04	2.2	126	10.2	6.9	7.0	81.4	
		5.15	21.7	4.1	7.2	1.7	97.1	0.0	2.9	21.0	0.00	0.01	0.19	0.08	0.04	2.7	108	9.4	10.7	6.9	71.1	
		6.15	23.1	3.7	5.6	1.0	102.9	0.0	0.6	21.1	0.00	0.00	0.02	0.03	0.13	2.9	106	17.5	3.5	6.8	73.0	
		Average	25.3	3.5	5.8	1.1	105.5	0.3	1.5	20.3	0.01	0.00	0.03	0.05	0.12	8.6	110.8	120.2	195.2	6.9	77.7	
Nan River	Pitsanuloke	1956. 7.15	13.2	2.5	3.0	1.9	59.3	0.0	0.7	15.5	0.01	0.00	0.05	0.03	0.28	16.4	68	—	906.6	6.5	43.4	
		8.15	12.4	2.1	2.7	1.3	57.1	0.0	0.3	21.6	0.01	0.00	0.00	0.06	0.96	95.0	62	937.7	1118.6	6.4	39.5	
		10.15	16.6	3.5	5.3	1.5	81.0	0.0	2.1	16.1	0.00	0.00	0.01	0.02	0.01	22.5	88	188.2	107.7	6.8	55.8	
		11.15	24.6	4.5	7.9	1.2	110.9	0.8	7.6	17.1	0.01	0.03	0.00	0.01	0.00	12.4	116	82.0	16.0	7.1	79.8	
		12.15	28.3	5.7	9.2	1.2	123.1	0.0	8.4	18.5	0.00	0.00	0.01	0.02	0.01	4.6	130	28.8	9.6	6.9	94.3	
		1957. 1.15	37.2	6.0	10.5	1.4	128.9	0.0	9.7	21.6	0.00	0.01	0.00	0.06	0.03	6.1	149	44.9	15.2	7.0	117.8	
		2.15	30.7	6.2	11.2	1.7	132.3	0.7	11.0	20.6	0.00	0.01	0.00	0.03	0.05	1.9	144	45.4	9.8	7.1	102.1	
		3.15	30.1	5.7	12.2	2.2	134.5	0.0	13.8	21.3	0.00	0.01	0.00	0.06	0.06	1.7	152	66.9	18.7	6.9	98.7	
		4.15	28.7	5.4	11.2	2.3	124.2	1.6	11.3	21.2	0.00	0.00	0.00	0.04	0.04	1.5	141	66.0	21.2	6.8	93.9	
		5.15	17.3	2.8	7.0	3.6	74.3	0.0	7.7	12.2	0.01	0.00	0.03	0.03	1.18	15.8	91	1436.4	2521.3	6.6	54.6	
		6.15	18.2	3.1	4.7	5.2	81.8	0.0	2.9	17.5	0.00	0.00	0.00	0.06	0.04	4.6	97	407.1	305.0	6.8	58.0	
		Average	23.4	4.3	7.7	2.1	101.6	0.3	6.9	18.5	0.00	0.00	0.01	0.04	0.24	16.6	112.5	330.3	459.1	6.8	76.2	
Yom River	Sukhothai	1956. 7.15	26.7	4.1	6.0	2.8	110.4	4.8	0.0	21.3	0.00	0.00	0.05	0.04	0.17	14.7	118	—	321.6	6.7	83.4	
		8.15	24.6	3.9	4.7	1.9	103.7	2.2	0.0	18.5	0.00	0.00	0.01	0.01	1.16	96.8	108	1294.3	1312.8	6.6	77.5	
		9.15	21.3	3.9	4.2	1.7	92.9	0.0	0.0	18.8	0.04	0.00	0.03	0.00	0.60	34.5	94	796.2	807.4	6.6	69.3	
		10.15	34.5	5.8	7.5	1.7	150.0	3.0	0.0	18.6	0.00	0.00	0.01	0.04	0.01	24.8	144	212.6	127.2	6.9	109.9	
		11.15	37.2	6.9	8.0	1.9	161.9	3.4	0.4	19.5	0.01	0.00	0.04	0.02	0.00	9.5	162	88.6	109.4	7.0	121.5	
		12.15	38.2	7.4	8.3	2.1	169.1	0.0	1.6	21.3	0.01	0.00	0.01	0.02	0.01	5.9	165	81.0	13.9	7.0	125.8	
		1957. 1.15	39.6	7.5	10.4	2.7	175.2	0.2	0.9	24.2	0.00	0.00	0.00	0.03	0.02	5.8	168	52.5	23.5	7.0	129.9	
		2.15	38.7	8.1	10.9	3.0	174.1	5.0	1.9	23.5	0.00	0.00	0.00	0.02	0.12	2.7	175	46.0	8.3	7.0	130.2	
		3.15	36.5	8.3	12.2	4.3	180.2	3.0	1.3	24.2	0.00	0.00	0.26	0.08	0.26	1.7	183	79.2	12.7	6.9	125.4	
		4.15	31.0	6.9	10.8	4.1	151.1	4.3	0.6	24.7	0.00	0.01	0.00	0.04	0.05	1.9	163	85.1	53.3	6.9	106.0	
		5.15	25.2	5.1	6.5	4.4	112.9	4.7	0.0	20.7	0.00	0.00	0.00	0.03	0.07	2.4	124	302.3	227.9	6.7	83.9	
		6.15	25.7	4.2	5.5	3.1	108.1	7.7	0.0	17.9	0.00	0.00	0.00	0.05	0.01	3.2	117	226.6	43.0	6.6	81.4	
		Average	31.6	6.0	7.9	2.8	140.8	3.2	0.6	21.1	0.01	0.00	0.03	0.03	0.21	17.0	143.4	296.8	255.0	6.8	103.7	

Mae Nam Chao Phraya	Uthai Thani	1956. 8.15	4.5	0.7	5.3	3.2	35.5	1.2	0.7	19.0	0.29	0.01	0.06	0.01	0.10	47.6	63	—	300.6	6.1	14.2
		9.15	6.4	1.2	3.3	2.3	35.8	0.0	0.0	15.9	0.03	0.01	0.00	0.01	0.17	7.2	50	38.4	23.2	6.2	20.8
		10.15	11.6	2.2	3.8	2.5	58.5	0.0	0.0	15.3	0.01	0.01	0.01	0.04	0.02	4.6	70	26.8	7.0	6.6	37.8
		11.15	12.4	2.6	5.3	2.6	66.5	0.0	1.3	16.5	0.01	0.00	0.05	0.02	0.01	6.9	78	34.5	19.6	6.6	41.5
		12.15	11.5	2.7	7.5	3.5	61.3	0.0	5.9	20.6	0.01	0.01	0.04	0.09	0.04	14.1	91	33.5	34.0	6.6	39.7
		1957. 1.15	12.5	2.8	10.2	3.9	73.8	0.0	2.0	24.7	0.00	0.02	0.00	0.06	0.16	12.0	96	13.3	4.0	6.6	42.6
		2.15	15.7	3.7	15.5	4.0	86.0	0.0	6.6	21.5	0.01	0.00	0.01	0.06	0.02	2.8	105	13.0	4.2	6.7	54.5
		3.15	17.8	3.9	11.4	4.5	96.2	0.0	10.0	13.9	0.01	0.00	0.13	0.14	0.26	2.7	114	254.4	12.8	6.7	60.3
		4.15	9.7	2.0	9.8	9.8	61.6	0.0	10.6	16.9	0.02	0.00	0.00	0.03	0.09	2.3	100	100.7	40.1	6.5	32.5
		5.15	12.5	3.1	12.2	6.9	70.2	0.0	14.2	15.5	0.00	0.01	0.45	0.04	0.11	5.2	108	13.1	14.1	6.6	43.9
		6.15	22.7	4.2	11.7	5.1	108.7	0.0	13.2	18.6	0.00	0.01	0.01	0.05	0.16	2.9	137	13.3	2.6	6.7	73.9
		7.15	22.4	3.7	9.8	4.2	105.6	0.0	9.2	20.0	0.01	0.01	0.01	0.12	0.02	—	124	9.7	21.1	7.1	71.3
		Average	13.3	2.7	8.8	4.4	71.6	0.1	6.1	18.2	0.03	0.01	0.06	0.06	0.10	9.8	94.7	50.0	40.3	6.6	44.4
Mae Nam Chao Phraya	Ayuthaya	1956. 7.15	13.7	1.8	4.2	3.0	61.0	0.8	0.7	22.9	0.10	0.00	0.27	0.05	0.39	12.0	88	—	460.7	6.5	41.7
		8.15	13.6	1.7	3.0	2.1	58.8	0.7	0.3	18.1	0.02	0.00	0.01	0.02	0.56	64.8	73	653.7	736.0	6.4	40.9
		9.15	13.7	2.2	3.4	2.2	63.2	0.0	0.6	19.9	0.10	0.00	0.00	0.03	0.03	18.1	80	329.9	290.8	6.5	43.3
		10.15	14.3	2.6	4.2	2.1	68.8	0.5	0.0	15.0	0.00	0.00	0.01	0.05	0.02	5.2	77	51.3	4.6	6.5	46.4
		11.15	16.7	3.0	4.5	1.5	79.3	0.5	0.3	15.1	0.03	0.01	0.01	0.02	0.00	6.2	86	28.4	17.8	6.9	54.2
		12.15	24.8	4.3	7.2	2.3	109.8	1.7	5.5	17.8	0.01	0.00	0.01	0.11	0.06	6.8	119	8.2	5.4	6.8	79.4
		1957. 1.15	29.2	4.8	11.3	3.2	125.1	1.9	10.3	21.8	0.01	0.00	0.00	0.04	0.15	6.2	143	48.2	35.4	6.8	92.8
		2.15	33.1	4.7	13.1	3.4	141.4	2.6	15.6	17.1	0.00	0.00	0.00	0.06	0.01	2.2	165	65.8	14.4	6.9	102.0
		3.15	27.1	4.8	10.1	3.8	119.5	0.7	10.6	17.5	0.00	0.00	0.00	0.05	0.06	2.1	140	82.6	33.7	6.7	87.5
		4.15	31.3	6.6	16.8	4.2	134.5	0.8	22.5	18.7	0.00	0.00	0.00	0.05	0.04	1.7	167	60.0	15.6	6.9	105.5
		5.15	33.5	6.6	16.6	6.1	149.2	2.5	18.5	18.6	0.00	0.00	0.03	0.05	0.59	0.8	181	104.6	43.3	6.8	111.0
		6.15	19.3	3.3	6.2	3.9	86.0	1.1	5.5	16.5	0.00	0.00	0.00	0.07	0.08	4.8	119	680.3	473.1	6.6	61.8
		Average	22.5	3.9	8.4	3.2	99.7	1.2	7.5	18.3	0.02	0.00	0.03	0.05	0.17	10.9	119.8	192.1	177.6	6.7	72.2
Pa Sak River	Petchabun	1956. 7.18	15.6	3.3	6.0	3.7	76.0	0.6	0.0	21.7	0.06	0.01	0.18	0.05	0.20	13.5	95	—	404.9	6.3	52.3
		8.18	16.1	3.3	4.7	3.8	77.1	3.6	0.0	21.1	0.01	0.05	0.00	0.01	0.00	25.5	93	110.9	41.7	6.3	53.8
		9.18	24.1	4.7	6.2	2.1	112.6	4.0	0.0	20.9	0.01	0.00	0.00	0.00	0.02	5.9	116	60.0	13.4	6.6	79.5
		10.18	30.2	4.9	8.9	1.5	136.7	5.8	0.1	18.6	0.00	0.00	0.04	0.02	0.33	2.8	143	153.8	227.7	6.7	95.4
		11.18	33.6	6.8	9.2	1.7	147.0	7.4	1.2	21.2	0.01	0.05	0.00	0.01	0.11	4.3	155	78.0	40.9	7.1	111.9
		12.18	34.9	6.9	9.7	2.0	152.2	5.8	1.6	20.8	0.00	0.00	0.01	0.02	0.07	6.3	157	118.6	15.4	6.9	115.8
		1957. 1.18	36.9	7.2	11.2	2.8	160.6	9.1	2.1	26.6	0.00	0.00	0.02	0.03	0.32	8.0	173	176.9	48.5	6.9	122.0
		2.18	38.0	7.5	11.7	3.5	168.0	8.6	2.0	26.3	0.00	0.00	0.00	0.07	0.01	1.7	178	296.8	48.5	6.9	125.8
		3.18	24.3	4.8	8.2	2.9	111.2	9.4	1.9	22.8	0.08	0.01	0.00	0.04	0.93	1.8	127	466.9	649.4	6.6	80.5
		4.18	37.3	7.8	14.0	5.7	159.7	20.8	4.1	28.8	0.00	0.00	0.03	0.03	0.05	2.4	200	200.3	132.7	6.6	125.4
		5.18	19.5	8.1	17.5	5.6	162.2	14.0	6.3	32.6	0.01	0.00	0.23	0.02	0.24	—	178	215.2	636.9	6.7	82.2
		6.18	22.4	5.4	6.6	3.6	111.7	3.0	0.0	23.3	0.00	0.02	0.31	0.06	0.07	4.6	125	512.8	173.5	6.6	78.2
		Average	27.8	5.9	9.5	3.2	131.3	7.7	1.6	23.7	0.02	0.01	0.07	0.03	0.20	7.0	145.0	217.3	202.8	6.7	93.6

Name of river	Places of sampling	Date of collection	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Fe	PO_4	NO_3-N	NH_4-N	Albuminoid-N	$KMnO_4$ consumed	Dissolved solids	Suspended solids	Turbidity*	pH	Hardness**	Note
Pa Sak River	Saraburi	1956. 7.15	12.1	1.0	3.0	3.6	50.7	0.6	0.0	17.0	0.06	0.00	0.34	0.04	0.33	19.7	74	—	256.5	6.2	34.5	
		8.15	21.6	2.8	7.2	3.6	89.0	2.0	3.0	23.9	0.01	0.00	0.52	0.11	0.25	5.4	121	57.7	5.0	6.4	65.6	
		9.15	16.7	2.5	4.5	2.8	77.9	0.8	0.0	22.2	0.03	0.09	0.00	0.00	0.21	21.0	94	143.4	43.5	6.7	52.0	
		10.15	24.3	3.9	5.9	2.7	110.1	0.0	0.0	16.6	0.00	0.00	0.00	0.05	0.01	17.2	117	48.7	7.6	6.6	76.8	
		11.15	57.2	6.5	7.5	2.1	198.0	0.0	4.0	18.1	0.01	0.05	0.00	0.03	0.01	5.8	207	21.7	11.6	7.2	169.8	
		12.15	71.7	7.5	8.3	2.0	256.8	0.0	4.3	19.6	0.01	0.00	0.00	0.01	0.00	3.6	249	54.3	7.7	7.1	210.0	
		1957. 1.15	58.8	6.6	8.8	2.2	183.8	0.0	4.4	23.8	0.00	0.00	0.12	0.04	0.05	5.5	230	65.7	17.4	7.2	174.2	
		2.15	73.8	6.6	8.0	2.1	244.9	0.0	5.9	20.5	0.00	0.01	0.00	0.02	0.01	1.7	259	77.1	1.0	7.2	211.7	
		3.15	57.2	7.2	8.3	2.7	181.3	0.0	8.1	18.1	0.01	0.01	0.00	0.03	0.02	1.2	217	89.3	1.5	7.1	172.6	
		4.15	35.9	3.8	6.0	4.0	134.2	0.0	3.6	20.6	0.00	0.00	0.00	0.05	0.04	2.2	148	46.7	26.3	6.7	105.2	
		5.15	60.7	4.8	6.8	3.9	203.2	0.0	6.1	19.3	0.00	0.00	0.00	0.06	0.11	3.8	219	54.9	11.3	6.9	171.5	
		6.15	71.3	5.4	5.6	3.3	245.4	0.0	7.3	8.7	0.00	0.00	0.00	0.06	0.01	1.8	253	65.7	3.7	6.9	200.5	
		Average	46.8	4.9	6.7	2.9	164.6	0.3	3.9	19.0	0.01	0.01	0.08	0.04	0.09	7.4	182.3	65.9	32.8	6.9	137.0	
Mae Nam Chao Phraya	Nonburi	1956. 7.15	15.1	2.0	5.0	3.0	62.4	2.2	2.9	17.4	0.10	0.00	0.33	0.03	0.47	14.7	91	—	723.9	6.5	45.8	
		8.15	13.8	2.2	3.8	2.0	58.5	3.8	1.0	18.5	0.01	0.00	0.00	0.00	0.02	20.3	75	183.4	234.9	6.5	43.6	
		9.15	14.1	2.7	4.9	2.2	58.5	4.2	1.8	17.8	0.01	0.01	0.00	0.04	0.01	9.8	78	83.3	32.1	6.5	46.3	
		10.15	13.4	2.7	4.7	1.7	64.3	1.7	0.6	14.5	0.00	0.00	0.01	0.35	0.19	5.7	80	13.6	6.5	6.5	44.7	
		11.15	15.7	3.0	5.0	1.4	75.7	0.4	0.2	14.5	0.01	0.01	0.00	0.01	0.11	5.1	86	20.4	7.1	6.9	51.4	
		12.15	21.2	4.3	7.0	2.1	98.7	0.0	4.3	15.0	0.00	0.00	0.00	0.23	0.24	6.4	104	22.8	0.6	6.8	70.4	
		1957. 1.15	26.8	5.1	11.1	3.1	114.5	0.2	10.7	19.5	0.00	0.00	0.00	0.03	0.30	7.3	135	116.7	17.1	6.8	88.0	
		2.15	30.2	6.3	12.6	3.2	124.2	3.6	15.6	18.3	0.00	0.00	0.07	0.04	0.04	2.5	160	200.3	7.6	6.8	101.6	
		3.15	30.7	6.5	13.7	3.5	130.3	6.7	18.8	16.4	0.00	0.00	0.00	0.07	0.34	1.4	161	91.4	10.7	6.8	103.3	
		4.15	33.9	6.9	16.2	4.3	137.0	8.2	22.9	17.3	0.00	0.00	0.00	0.03	0.04	1.7	174	74.8	22.1	6.9	113.3	
		5.15	31.0	7.8	23.4	5.8	132.8	9.2	31.8	16.6	0.01	0.01	0.00	0.08	0.05	2.1	188	117.3	12.9	6.8	109.9	
		6.15	32.0	7.5	17.1	5.4	138.1	6.4	22.4	12.3	0.01	0.00	0.00	0.05	0.01	2.2	177	104.2	48.0	7.0	111.0	
		Average	23.2	4.8	10.4	3.1	99.6	3.9	11.1	16.5	0.01	0.00	0.03	0.08	0.15	6.6	125.8	93.5	93.6	6.7	77.5	
Supan River	Supanburi	1956. 7.15	18.6	3.5	10.8	5.0	85.1	5.0	11.4	24.8	0.02	0.01	0.16	0.02	0.24	10.0	122	—	281.3	6.5	60.8	
		8.15	13.2	2.1	4.5	2.3	60.7	0.0	1.2	17.7	0.01	0.00	0.00	0.01	0.23	20.9	77	119.8	57.1	6.2	41.4	
		9.15	11.5	2.1	4.2	2.4	56.0	0.0	1.2	16.8	0.01	0.01	0.00	0.00	0.11	17.7	68	75.4	37.7	6.3	37.2	
		10.15	10.2	2.2	5.3	2.9	51.9	1.2	2.4	7.1	0.00	0.00	0.00	0.04	0.01	17.6	66	41.7	5.7	6.2	34.5	
		11.15	16.7	3.3	6.1	2.3	81.5	0.8	2.4	14.5	0.03	0.03	0.01	0.02	0.01	7.7	92	64.6	39.2	6.7	55.4	
		12.15	18.9	4.0	8.6	3.1	92.1	1.9	7.2	14.8	0.01	0.00	0.01	0.04	0.01	13.7	109	70.2	61.4	6.6	63.9	
		1957. 1.15	28.1	4.8	15.4	4.1	125.6	3.8	15.6	18.6	0.01	0.00	0.00	0.03	0.04	13.5	152	77.2	4.3	6.7	89.7	
		2.15	26.7	6.9	18.8	4.9	122.3	6.6	20.0	19.6	0.00	0.01	0.00	0.07	0.13	3.7	168	209.8	16.9	6.7	95.1	
		3.15	28.2	6.0	15.4	5.6	131.4	5.0	17.8	19.2	0.01	0.01	0.00	0.04	0.05	2.2	170	117.0	10.7	6.9	95.3	
		4.15	23.8	3.6	13.1	5.7	110.1	1.7	13.8	22.8	0.01	0.01	0.06	0.04	0.14	1.6	146	258.8	127.1	6.6	74.3	
		5.15	25.6	6.0	17.2	8.2	118.7	3.2	21.8	25.7	0.00	0.00	0.04	0.08	0.41	4.6	175	249.8	208.3	6.6	88.7	
		6.15	29.0	5.4	15.6	5.5	135.3	0.0	18.5	19.2	0.00	0.00	0.32	0.07	0.06	2.7	166	130.2	24.0	6.7	93.7	
		Average	20.9	4.2	11.2	4.3	97.6	2.4	11.1	18.4	0.01	0.01	0.05	0.04	0.12	9.7	125.9	128.6	72.8	6.6	69.2	

Kwae Noi River	Kanchanaburi	1956. 7.15	21.7	3.4	1.4	1.5	84.3	0.6	0.0	13.7	0.00	0.00	0.00	0.05	0.16	5.4	83	—	20.2	6.8	68.2
		8.	24.1	3.1	1.4	1.3	84.9	0.0	1.1	12.5	0.00	0.00	0.00	0.02	0.06	25.2	88	—	13.2	6.8	73.0
		9.	24.9	4.2	1.1	0.9	100.7	0.0	0.0	13.5	0.01	0.01	0.00	0.03	0.01	14.5	95	62.7	11.5	7.0	79.2
		10.	29.2	4.9	1.6	1.6	122.0	0.0	0.1	11.7	0.00	0.00	0.01	0.04	0.01	5.6	114	101.3	28.0	7.0	93.2
		11.15	37.4	7.8	1.9	2.0	160.6	0.0	1.2	12.4	0.00	0.12	0.01	0.03	0.00	3.2	143	7.9	2.2	7.3	125.5
		12.15	45.8	10.6	1.8	1.0	172.8	0.0	0.2	12.9	0.00	0.00	0.02	0.13	0.08	4.5	160	4.0	2.0	7.3	157.8
		1957. 1.15	37.2	10.6	2.4	1.2	189.7	0.0	1.3	13.6	0.00	0.00	0.01	0.03	0.03	4.9	152	31.4	4.2	7.2	136.2
		2.15	44.7	10.9	1.7	0.9	171.6	0.0	0.6	17.6	0.00	0.00	0.00	0.06	0.02	2.1	166	21.6	1.7	7.3	156.4
		3.15	38.6	12.7	1.9	1.4	156.7	0.0	1.3	10.9	0.00	0.01	0.02	0.08	0.16	1.9	153	43.6	0.0	7.3	148.5
		4.15	49.2	12.7	4.9	1.7	147.2	0.0	6.4	13.6	0.00	0.03	0.00	0.04	0.01	1.9	181	14.1	11.0	7.2	175.1
		5.15	38.4	12.4	2.6	2.1	220.2	1.0	1.5	15.1	0.00	0.00	0.00	0.05	0.07	1.4	183	43.7	2.7	7.3	146.7
		6.15	13.6	2.1	4.3	2.1	54.1	0.1	6.9	9.7	0.00	0.00	0.18	0.03	0.14	3.7	75	65.1	9.6	6.6	43.7
		Average	**33.8**	**8.0**	**2.3**	**1.5**	**138.7**	**0.1**	**1.7**	**13.1**	**0.00**	**0.01**	**0.02**	**0.05**	**0.06**	**6.2**	**132.8**	**39.5**	**8.9**	**7.1**	**116.9**
Mae Klong River	Bang Pong	1956. 7.15	24.6	3.8	1.9	1.9	96.5	0.5	0.0	13.1	0.00	0.00	0.15	0.07	0.13	5.7	113	—	11.7	6.8	77.0
		8.15	30.0	4.6	2.2	1.6	117.3	0.0	1.3	14.0	0.01	0.00	0.17	0.00	0.00	16.9	110	89.4	4.3	6.8	94.1
		9.15	31.4	4.7	1.8	1.4	122.8	0.0	0.6	14.0	0.01	0.01	0.14	0.16	0.13	3.5	115	73.6	33.3	6.9	97.9
		10.15	35.9	7.7	3.0	1.5	148.6	0.4	0.6	14.1	0.01	0.00	0.01	0.05	0.02	8.8	136	50.3	17.7	6.8	121.4
		11.15	40.4	6.3	2.9	1.4	169.1	1.6	1.2	14.6	0.01	0.00	0.08	0.01	0.00	5.5	154	32.3	9.7	7.3	126.6
		12.15	41.0	10.0	3.0	2.2	180.5	0.0	1.6	13.8	0.01	0.00	0.01	0.02	0.01	5.6	159	10.5	20.4	7.0	143.2
		1957. 1.15	45.0	12.1	4.6	1.8	196.0	0.0	3.9	15.1	0.01	0.00	0.00	0.08	0.02	5.8	179	55.5	14.4	7.1	161.9
		2.15	48.3	13.3	3.0	1.7	206.9	0.0	2.7	13.7	0.00	0.00	0.00	0.03	0.01	1.8	190	46.7	3.1	7.2	175.3
		3.15	46.0	12.1	2.8	1.9	223.2	0.0	3.1	12.7	0.03	0.00	0.00	0.06	0.03	1.9	184	29.2	8.3	7.1	164.4
		4.15	44.3	11.8	3.6	2.9	189.1	0.0	3.6	15.7	0.00	0.00	0.71	0.02	0.20	2.1	172	43.7	48.1	7.0	159.1
		5.15	44.0	13.9	5.3	2.2	215.7	0.0	5.6	16.1	0.01	0.00	0.00	0.05	0.06	2.7	197	51.0	26.9	7.1	166.8
		6.15	21.8	3.0	1.9	2.1	79.9	0.5	0.7	12.3	0.01	0.00	0.00	0.08	0.02	2.9	92	143.6	11.3	6.5	66.8
		Average	**37.7**	**8.6**	**3.0**	**1.9**	**162.1**	**0.2**	**2.1**	**14.1**	**0.01**	**0.00**	**0.11**	**0.05**	**0.05**	**5.3**	**150.1**	**56.9**	**17.4**	**7.0**	**129.5**
Chumphon River	Chumphon	1956. 7.15	9.0	2.7	4.1	2.7	46.3	0.2	3.3	23.2	0.03	0.00	0.14	0.03	0.12	10.0	71	—	10.9	6.5	33.4
		8.15	4.7	1.7	3.3	2.1	28.0	0.2	3.3	18.1	0.03	0.00	0.00	0.01	0.00	12.2	53	35.6	30.9	6.2	18.7
		9.15	5.8	2.2	3.3	2.2	37.2	0.4	2.4	22.4	0.01	0.00	0.00	0.08	0.01	5.0	60	33.4	1.9	6.3	23.6
		10.15	6.6	2.3	3.6	1.6	38.5	0.0	2.4	14.4	0.03	0.00	0.00	0.02	0.00	6.5	52	24.0	19.7	6.5	25.8
		11.15	8.4	2.5	3.7	1.4	45.5	1.0	3.3	15.9	0.14	0.00	0.01	0.01	0.00	4.6	55	28.1	9.7	6.7	31.1
		12.15	10.9	3.8	3.7	2.0	59.1	0.0	3.1	20.3	0.01	0.00	0.01	0.02	0.01	6.0	77	8.0	0.8	6.6	42.8
		1957. 1.15	12.6	4.8	6.2	2.5	68.2	0.0	6.3	23.1	0.00	0.00	0.01	0.19	0.07	8.1	91	11.6	1.6	6.7	51.3
		2.15	14.2	5.7	4.5	2.8	79.9	0.0	3.7	22.2	0.01	0.00	0.00	0.06	0.01	2.2	106	16.5	7.1	6.9	59.0
		3.15	14.2	6.6	4.9	3.5	84.9	0.0	5.3	25.4	0.02	0.00	0.03	0.07	0.03	2.2	99	10.2	4.1	6.8	62.6
		4.15	10.4	5.1	4.5	4.0	65.2	0.0	4.7	24.3	0.01	0.00	0.00	0.03	0.01	2.5	85	16.4	5.3	6.7	47.1
		5.15	6.1	3.3	3.8	3.7	42.7	0.1	2.7	22.8	0.00	0.00	0.07	0.07	0.07	4.1	66	20.7	2.6	6.4	29.0
		6.15	8.4	3.3	3.6	3.2	51.3	0.4	3.3	23.4	0.01	0.00	0.00	0.05	0.02	3.1	78	4.4	1.9	6.7	34.5
		Average	**9.3**	**3.7**	**4.1**	**2.7**	**53.9**	**0.2**	**3.7**	**21.3**	**0.03**	**0.00**	**0.02**	**0.05**	**0.03**	**5.5**	**74.4**	**19.0**	**8.0**	**6.6**	**38.2**

Name of river	Places of sampling	Date of collection	Ca	Mg	Na	K	HCO_3	SO_4	Cl	SiO_2	Fe	PO_4	NO_3-N	NH_4-N	Albuminoid-N	$KMnO_4$ consumed	Dissolved solids	Suspended solids	Turbidity*	pH	Hardness**	Note
Tapi River	Suratthani	1956. 7.17	9.3	2.4	3.7	1.7	41.0	0.5	3.9	13.5	0.00	0.00	0.08	0.03	0.13	11.1	57	—	4.1	6.4	32.9	
		8.15	6.0	1.7	2.0	1.3	26.9	0.0	2.3	12.3	0.01	0.02	0.00	0.10	0.16	12.2	35	166.2	32.4	6.2	22.2	
		10.15	7.9	1.7	1.9	1.0	35.8	1.0	1.6	9.8	0.02	0.00	0.00	0.02	0.01	7.3	44	35.5	8.8	6.4	26.8	
		11.15	9.3	2.0	6.5	1.9	34.1	1.0	7.5	9.8	0.00	0.02	1.53	0.01	0.01	9.7	73	27.3	5.0	6.2	31.4	
		12.15	14.5	3.9	5.0	1.5	60.2	0.0	6.9	11.9	0.01	0.00	0.18	0.05	0.06	15.6	84	23.1	16.9	6.4	52.4	
		1957. 1.15	12.6	4.5	7.7	1.3	58.0	0.0	11.6	13.0	0.01	0.00	0.01	0.05	0.02	5.2	84	37.5	3.3	6.5	49.8	
		2.15	—	—	—	—	—	—	117.8	—	—	—	—	—	—	—	—	—	—	—	—	Sea water mixed
		3.15	—	—	—	—	—	—	160.3	—	—	—	—	—	—	—	—	—	—	—	—	
		4.16	—	—	—	—	—	—	67.2	—	—	—	—	—	—	—	—	—	—	—	—	
		5.15	—	—	—	—	—	—	63.2	—	—	—	—	—	—	—	—	—	—	—	—	
		6.15	—	—	—	—	—	—	40.6	—	—	—	—	—	—	—	—	—	—	—	—	
		Average	9.9	2.7	4.5	1.5	42.7	0.4	*** 5.6	11.7	0.01	0.01	0.30	0.04	0.07	10.2	62.8	57.9	11.8	6.4	35.9	
Lake Talesaab	Patthalung	1956. 7.15	—	—	—	—	—	—	364.2	—	—	—	—	—	—	—	—	—	—	—	—	Sea water mixed
		8.15	—	—	—	—	—	—	2907.4	—	—	—	—	—	—	—	—	—	—	—	—	
		10.15	—	—	—	—	—	—	22.7	—	—	—	—	—	—	—	—	—	—	—	—	
		11.15	8.1	0.8	2.4	0.8	32.7	0.0	1.2	8.9	0.06	0.00	0.01	0.07	0.11	7.3	50	22.6	20.7	6.4	23.6	
		12.15	9.4	0.7	2.7	0.6	36.9	0.0	2.5	7.3	0.00	0.00	0.01	0.08	0.23	8.6	50	16.0	5.4	6.3	26.3	
		1957. 1.15	9.4	0.7	2.8	0.8	35.2	0.0	2.5	8.4	0.01	0.00	0.00	0.05	0.22	9.6	48	21.7	7.3	6.3	26.3	
		2.15	—	—	—	—	—	—	4953.8	—	—	—	—	—	—	—	—	—	—	—	—	Sea water mixed
		3.15	15.2	0.5	4.4	0.8	57.4	0.2	3.8	16.0	0.00	0.00	0.00	0.14	0.34	2.0	74	12.1	2.5	6.7	39.1	
		4.16	11.9	0.7	4.0	1.0	42.4	0.1	3.4	15.7	0.01	0.00	0.35	0.05	0.01	—	61	12.2	11.2	6.5	32.4	
		5.15	15.7	1.0	4.2	1.7	60.2	0.0	3.4	17.9	0.01	0.00	0.00	0.05	0.01	4.3	78	7.4	3.7	6.7	43.3	
		6.15	13.7	1.0	3.9	2.2	54.6	0.0	3.5	16.0	0.00	0.00	0.01	0.15	0.04	3.5	76	5.3	1.0	6.6	38.2	
		Average	11.9	0.8	3.5	1.1	45.6	0.0	*** 2.9	12.9	0.01	0.00	0.05	0.08	0.14	5.9	62.4	13.9	7.4	6.5	32.7	
Sai Buri River	Narathiwat	1956. 7.15	2.4	0.8	2.7	1.8	18.9	0.8	0.7	20.6	0.03	0.00	0.09	0.09	0.16	5.9	41	—	3.4	6.2	9.5	
		8.15	2.1	0.8	2.6	1.3	16.6	0.2	0.8	18.6	0.01	0.00	0.07	0.00	0.00	10.1	38	19.2	8.3	6.2	8.8	
		10.15	2.1	0.8	2.2	1.1	16.9	0.2	1.0	13.4	0.03	0.00	0.00	0.04	0.00	13.9	33	32.1	28.9	6.1	8.5	
		11.15	1.9	0.8	2.2	1.0	15.3	0.0	1.0	13.4	0.03	0.00	0.02	0.03	0.00	9.2	35	34.5	7.2	6.1	7.9	
		12.15	1.9	0.8	2.4	1.1	15.0	0.0	2.2	15.8	0.02	0.00	0.01	0.03	0.06	5.7	35	19.0	6.0	6.2	8.1	
		1957. 1.15	1.6	0.6	2.3	1.1	14.1	0.0	1.2	15.8	0.01	0.00	0.01	0.03	0.02	7.1	34	29.9	4.2	6.2	6.6	
		2.15	2.1	0.8	2.6	1.2	17.2	0.4	1.6	17.1	0.00	0.00	0.00	0.01	0.02	2.1	39	13.8	3.6	6.3	10.4	
		3.15	1.8	0.7	2.4	1.6	14.1	0.2	1.3	14.7	0.02	0.01	0.03	0.06	0.35	3.6	35	82.6	19.4	6.0	7.4	
		4.15	2.0	0.7	2.5	1.4	16.6	0.0	1.3	16.4	0.05	0.00	0.00	0.07	0.04	2.8	36	8.9	5.3	6.2	8.0	
		5.15	1.1	0.5	1.9	1.5	11.6	0.1	0.1	12.7	0.01	0.00	0.03	0.05	0.09	4.7	26	61.2	25.8	5.8	4.7	
		6.15	2.1	0.9	2.4	1.2	18.0	0.4	0.7	16.6	0.02	0.01	0.00	0.04	0.04	2.1	36	12.2	3.7	6.2	9.1	
		Average	1.9	0.7	2.4	1.3	15.8	0.2	1.1	15.9	0.02	0.00	0.02	0.04	0.07	6.1	35.3	31.3	10.5	6.1	8.1	

*** Calculated without the samples sea water mixed.

City Water	Bangkok	1957. 3.15	29.4	6.0	14.6	4.2	113.1	18.7	19.1	15.1	0.00	0.00	0.18	0.06	0.02	—	173	—	2.2	7.1	98.3
		4.15	30.0	6.2	14.9	4.0	103.2	22.2	19.2	15.0	0.01	0.01	0.32	0.12	0.06	—	168	—	0.0	6.9	100.3
		5.15	31.8	6.3	25.5	5.7	114.5	21.0	23.0	15.2	0.00	0.00	0.47	0.05	0.03	—	212	—	5.1	7.3	105.2
		6.15	31.6	6.2	25.6	5.9	134.8	24.5	22.6	14.5	0.00	0.00	0.23	0.08	0.01	—	210	—	1.7	7.1	104.4
		7.15	23.4	3.1	14.1	4.0	81.8	40.0	8.5	20.4	0.03	0.01	0.45	0.14	0.09	—	154	—	6.8	7.2	71.4
		8.15	24.5	4.2	18.4	3.3	41.9	75.0	15.9	17.0	0.06	0.00	0.40	0.08	0.01	—	195	—	3.2	7.0	78.6
		9.15	19.7	12.1	31.2	3.2	17.7	72.6	18.4	7.0	0.15	0.01	0.12	0.06	0.01	—	259	—	12.1	6.6	98.9
		10.15	9.4	5.7	19.0	1.6	20.8	49.2	9.6	5.3	0.06	0.00	0.02	0.05	0.01	—	108	—	4.7	6.7	47.1
		12.15	9.9	3.9	17.8	1.6	32.4	37.2	8.3	8.5	0.01	0.00	0.00	0.03	0.01	—	113	—	5.0	7.2	40.9
		1958. 1.15	12.0	1.7	10.1	1.8	54.3	18.5	4.9	12.1	0.09	0.01	0.04	0.01	0.11	—	97	—	2.9	7.4	37.2
		2.15	30.2	7.8	19.3	3.5	165.5	20.4	15.5	20.1	0.01	0.00	0.04	0.03	0.01	—	186	—	2.4	7.4	107.6
		Average	**22.9**	**5.7**	**19.1**	**3.5**	**80.0**	**36.3**	**15.0**	**13.6**	**0.04**	**0.00**	**0.20**	**0.06**	**0.03**	—	**170.5**	—	**4.2**	**7.1**	**80.9**
Total average of 30 places except city water.			**19.8**	**3.7**	**10.7**	**2.5**	**82.6**	**3.3**	**12.7**	**16.0**	**0.04**	**0.01**	**0.08**	**0.06**	**0.12**	**8.3**	**115.2**	**112.0**	**111.6**	**6.6**	**64.7**

III. METHODS OF ANALYSIS

In consideration of the necessity to compare the nature of waters in Thailand and Japan, the methods of analysis I used in the chemical investigation of Japanese river water in the past have been adopted. The outline of the methods is as follows:

(a) *Calcium.*

The sample is kept still and taking the supernatant clear portion, it is evaporated to dryness and the residue is treated with hydrochloric acid to separate silica away. Calcium is precipitated as an oxalate as usual. After filtering and washing, the precipitate is dissolved in sulfuric acid and isolated oxalic acid is titrated with potassium permanganate solution.

(b) *Magnesium.*

In accordance with the standard methods of the American Public Health Association (1946), the sample is added with each of the following reagents: sulfuric acid, starch, calcium sulfate, titan yellow and sodium hydroxide solutions. Pink color developed is measured colorimetrically.

(c) *Sodium and Potassium.*

Flame analysis equipment attached with spectrophotometer and self-recorder is used.

(d) *Alkalinity* (HCO_3).

It is calculated from the value of titration with acid up to pH 4.3 which is the mid-color comparing with the two colors produced by the buffer solutions of pH 4.2 and 4.4 using bromcresol-green as indicator.

(e) *Sulfate.*

It is the shortcoming of the barium sulfate weight method that great quantity of sampling water is required in order to get precise results.

Therefore I improved on benzidine method (Fiske 1921, Iwata 1936) as follows:

20—50 cc of the sampling water is evaporated to dryness in a micro-beaker (Shioiri, and Nagahara, 1933: Shioiri, and Yoneda, 1940: Iwasaki, 1941). The precipitate produced by mixing 1 cc of pure water, 0.2 cc benzidine reagent and 0.5 cc acetone is left overnight. After filtered by micro-analysis filter stick packed with filter-paper fibre instead of asbestos, and washed with acetone, the precipitate is taken out together with the filter paper fibre into the original micro-beaker by a pin point.

With filter-stick inside, and after adding about 20 cc of pure water, boiling is continued until it is concentrated up to about 1 cc. This is titrated by 1/100 N alkali solution using phenol-red as indicator, and the SO_4 content is calculated after the value of control test is deducted.

The precipitate of benzidine sulfate sticking to the inside wall of the beaker is offen hard to be completely dissolved while being boiled. Therefore, it should be boiled until it is completely dissolved scrubbing carefully the inside wall of the beaker with the end of the filter-stick. I noticed cases where the results were unduly low on account of the existence of impurity in benzidine sulfate precipitate. Therefore I adopted the value after repeated titration of the reprecipitated sulfate from the first titrated solution.

(f) *Chloride.*

It is titrated with silver nitrate solution using micro-burette, with potassium chromate solution as indicator. In case the sample water contains little chloride, it is noticed that there is a tendency of the results becoming excessive even after the deduction of the value of control test. Therefore, when the titration is made, standard solutions such as 0.5, 1.0, 2.0 ppm etc. are prepared in addition to pure water. Both of them are titrated and compared in order to make the end point more precise.

(g) *Silica.*

The yellow color produced by sulfuric acid and ammonium molybdate is measured by spectrophotometer.

(h) *Iron.*

After taking away the suspended sediment by keeping the sample water still, iron is determined by thiocyanate colorimetric method. In case of the abundance of suspended sediment, they were taken away by using the centrifuge.

(i) *Phosphate.*

Colorimetric method with ammonium molybdate and stannous chloride.

(j) *Nitrate nitrogen.*

Colorimetric by means of diphenylamine method.

(k) *Ammonia nitrogen.*

Following the A. O. A. C. (1940), the sample water is distilled with small quantity of sodium carbonate solution. The distillate is colori-measured by Nessler's reagent. However, in case rubber or cork stopper is used in the distillation apparatus, ammonia analogues are distilled which give the color with Nessler's reagent and make the analytical results excessive. In order to avoid this, ground glass is used in the connecting part of the distillation apparatus and also a small-sized flask is used in order to save the volume of sample water.

(l) *Albuminoid nitrogen.*

Alkaline permanganate solution is added to the contents of the distilling flask after removal of ammonia from the sample, distillation is continued, and distillate is Nesslerized. (A. O. A. C. 1940)

(m) *Dissolved solids.*

The clear portion of the sample water after either being kept still or suspended solids being taken away by means of a centrifuge of 20,000 rotations per minute, is evaporated and weighed. When platinum dish is used while weighing, moisture is absorbed by the evaporated residue resulting in excessive figures due to the high humidity in Japan. For thus reason, a special weighing bottle with cover is used.

(n) *pH.*

Colorimetric method.

(o) *Hardness.*

It is calculated from the content of calcium and magnesium.

IV. ANALYTICAL RESULTS AND DISTRIBUTION OF CONSTITUENTS IN THAILAND

Table 2 shows the analytical results of waters, which were obtained simultaneously 12 times during a year at 31 different places mentioned previously. According to the results, the general conditions of the nature of water in Thailand are as follows as classified by constituents.

(a) *pH.*

So far as the reaction is concerned, predominant samples of the waters in Thailand show weak acidity. Waters from 22 places among 31 places show the reaction of or less than pH 6.8 for the average of 12 times during a year. The lowest ones are pH 5.9 in the upper stream of the Mun River (at Surin), 6.0 in the Bang Pakong River, 6.1 in the Chantaburi River, Lake Nong Han, and the Sai Buri River which is in the Malay peninsula, the southern most part of Thailand. The Phao River, the Mun River (at Ubolrajatani), the Tapi River and the Prachin River show 6.4. The Chi River (at Chaiyaphum) and Lake Talesaab show 6.5. Thus many waters show weak acid reaction. As for rivers showing neutral or alkaline reaction there are only 2, i. e. pH 7.0 in the Mae Klong River and 7.1 in the Kwae Noi River.

As will be stated later, the waters of Thailand are more affected by the solution of limestone than in Japan and yet show acid reaction on the contrary. The reason for this phenomenon can be explained by the influence of organic matters in view of the tendency of the abundance of potassium per-

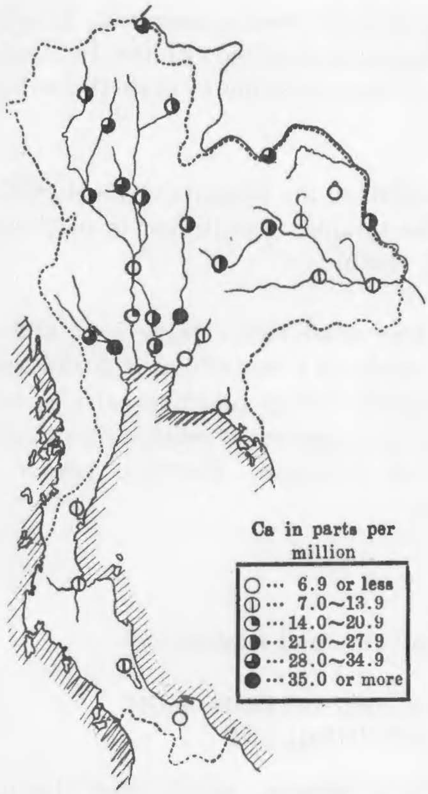


Fig. 2. Distribution of calcium content. (Average value during one year.)

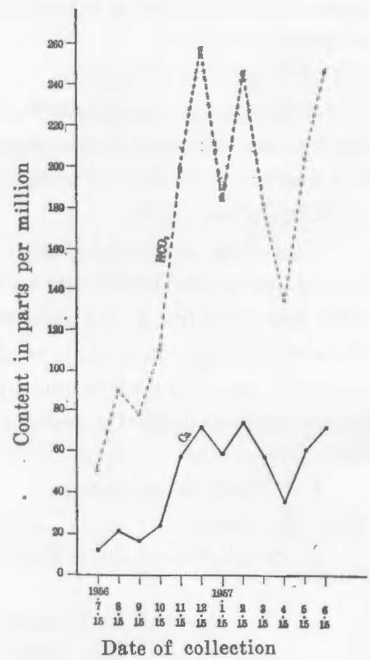


Fig. 3. Change of calcium content and alkalinity in the Pa Sak River during one year.

manganate consumed.

(b) *Calcium.*

As for the content of Ca dissolved in the water, there are great differences between rivers. The Chantaburi River on the east coast and the Sai Buri River in the Malay peninsula show only an average value of 1.9 ppm during a year while the Pa Sak River (at Saraburi) which flows southward in the central part of Thailand shows as high as 46.8 ppm. Next to the Pa Sak River, 37.7 ppm in the Mae Klong River, 33.8 ppm in the Kwae Noi River which is the upper stream of the Mae Klong River, 32.1 ppm in the Mae Khong River (at Chiengsan) etc. are some of the examples of waters containing abundance of Ca. On the other hand, besides the above mentioned Chantaburi River and the Sai Buri River, 3.0 ppm in Lake Nong Han and 3.4 ppm in the Bang Pakong River etc. are some of the waters short in Ca content.

The distribution of Ca content in Thailand is shown in Fig. 2. It has been found out that the two basins of the Mae Nam Chao Phraya and Mae Klong and the main stream of the Mae Khong River contain large quantity of Ca, showing big influence of limestone while there is a tendency that the waters of the Malay peninsula, the east coast of Thailand and the eastern part of Korat Plateau contain small quantity of Ca.

The change of Ca content during a year of the water in the Pa Sak River which has the highest value is shown in Fig. 3. Ca content reached the peak of 73.8 ppm on February 15, 1957 which was in the dry season. This is about 6 times in density compared with the lowest value of 12.1 ppm shown on July 15, 1956 in the rainy season. Moreover, the samples collected during the dry season from the Pa Sak River, after having been stored in my laboratory for one year showed that Ca and alkalinity decreased almost by half. It is clear that $CaCO_3$ was taken out as precipitate.

On the other hand, the Sai Buri River which has less influence of limestone and least Ca content shows 2.4 ppm at the peak and 1.1 ppm at the lowest, thus indicating far smaller scope of seasonal change compared with the Pa Sak River.

(c) *Magnesium.*

The scope of Mg content ranges from 0.7 to 8.6 ppm. The differences between rivers are great as in the case of Ca. The highest is 8.6 ppm in the Mae Klong River followed by 8.0 ppm in the Kwae Noi River which is the upper stream of the same river. Other rivers such as the Yom River flowing in the upper basin of the Mae Nam Chao Phraya, the main stream of the Mae Khong River, the Pa Sak River etc. contain comparatively large amount.

On the other hand, there is a tendency that the rivers flowing in the Malay peninsula, the east coast of Thailand and the Korat Plateau contain less, the least of these being 0.7 ppm in Lake Nong Han, the Chantaburi River and the Sai Buri River.

The general outlook of the distribution of Mg content in Thailand is shown in Fig. 4. Generally speaking, rivers containing abundance of Ca tend to abound in Mg and rivers with little Ca have the tendency to contain little Mg.

(d) *Sodium.*

It is considered that a formation of rock-salt occurs inside the sand stones of Korat stratum which constitutes the Korat Plateau in the eastern part of Thailand (Thai Royal Department of Mines 1953). On account of the influence of the exuding salt, rivers flowing through this area contain large quantity of Na.

The Chi River flowing eastward in the central part of the Korat Plateau shows an average of 57.1 ppm at Kon Khen during one year. The Mun River flowing eastward on the south side of the Chi River shows 40.0 ppm at Ubolrajatani and 28.7 ppm at Surin. The Phao River contains 23.6 ppm.

The Chi River (at Kon Khen) which shows the highest average value recorded 192.9 ppm at the peak during the dry season as indicated in Fig. 5. However, it came down to only 3.9 ppm at the lowest during the wet season thus indicating a great change in density. However, the content of Na at

Fig. 4. Distribution of magnesium content. (Average value during one year.)

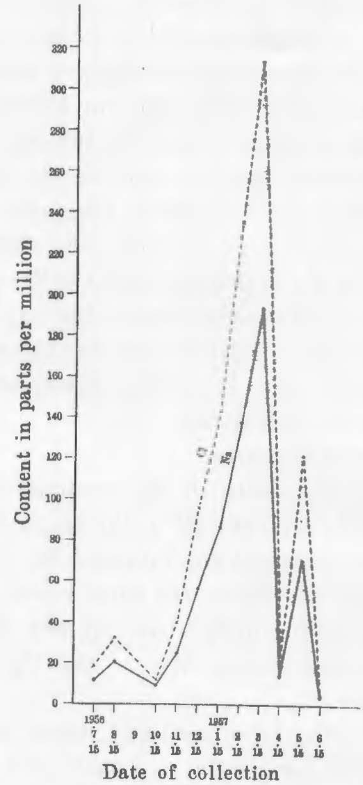


Fig. 5. Change of sodium and chloride content in the Chi River at Kon Khen during one year.

Chaiyaphum in the upper stream region of the Chi River is remarkably small compared with that at Kon Khen, being 38.3 ppm at the peak, 1.5 ppm at the lowest and an average of 14.1 ppm during one year. Therefore, it has been found out that Na content in the river waters of the Korat Plateau not only changes according to the season, but also shows great differences depending on the places.

In the area outside of the Korat Plateau there were times when Na increased in the Bang Pakong River, the Tapi River and Lake Talesaab due to the infiltration of sea water. Also, the city water of Bangkok showed comparatively high figures due to its proximity to the sea coast, such as 31.2 ppm at the peak, 10.1 ppm at the lowest and an average of 19.1 ppm during one year.

Except the above mentioned rivers the average content in other rivers during one year is within the scope of 2.3—11.2 ppm. From among these, the Kwae Noi, Chantaburi, Sai Buri, Mae Klong and Ping (at Chiengmai) rivers showed to be very dilute in Na content.

The distribution of Na in Thailand is shown in Fig. 6. The rivers flow-

Fig. 6. Distribution of sodium content. (Average value during one year.)

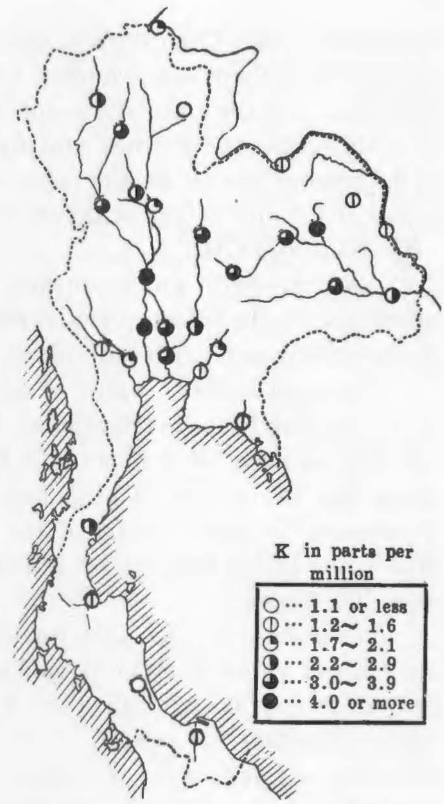


Fig. 7. Distribution of potassium content. (Average value during one year.)

ing in the Korat Plateau contain great quantity of Na while it is small in the Malay peninsula, the upper stream regions of the Mae Nam Chao Phraya and the basin of the Mae Klong River.

(e) *Potassium.*

It is needless to say that K is an important component of fertilizer. K is most contained in the river water among the three fertilizing elements (N, P, K).

Among the 31 places investigated, the highest average content of K during one year was 4.4 ppm in the middle stream region (Uthai Thani) of the Mae Nam Chao Phraya followed by 4.3 ppm in the Supan River, 4.2 ppm in the Phao River etc. Many waters including 2 places of the Chi River (Chaiyaphum and Kon Khen), the Mun River (at Surin), the Wang River (at Lampang), the Ping River (at Tak), the Pa Sak River (at Petchabun), 2 places of the lower stream of the Mae Nam Chao Phraya (Ayuthaya and Nonburi) etc. showed high values over 3.0 ppm. On the other hand, low K content was 1.1 ppm in the Nan River (at Nan) and Lake Talesaab and 1.3 ppm in the Sai Buri River.

The distribution of K content in Thailand is shown in Fig. 7. The basin of the Mae Nam Chao Phraya and the rivers in the Korat Plateau have high values while there is a tendency that the Malay peninsula, the east coast of Thailand and the main stream of the Mae Khong River show low values.

However, the average content of K in 28 rivers and 2 lakes of Thailand is 2.5 ppm as shown in the lower end of Table 2 corresponding to about 2 times of 1.3 ppm which is the average of Japan.

(f) *Alkalinity* (HCO_3).

Natural river water contains bicarbonate through dissolution of limestone having the effect of neutralizing acidity of the soil. On the other hand, in industrial water it is a disadvantage in that it promotes hardness of water.

The highest HCO_3 value of an average during one year was 164.6 ppm in the Pa Sak River (at Saraburi). The upper stream of the same river (at Petchabun) showed 131.3 ppm; the Mae Klong River showed 162.1 ppm; the Kwae Noi River showed 138.7 ppm; the Yom River showed 140.8 ppm and 3 places in the main stream of the Mae Khong River, the Ping, Wang and Nan Rives in the basin of the Mae Nam Chao Phraya etc. showed high values over 100. 0 ppm.

The change of alkalinity during one year of the Pa Sak River which has the highest value of HCO_3 is indicated in Fig. 3 in which it can be noticed that 256.8 ppm is the peak while 50. 7 ppm is the lowest. Especially it was remarkable that the samples which were collected in the dry season and were stored in my laboratory for about one year showed that Ca and HCO_3 decreased by half and $CaCO_3$ was actually precipitated. This will never happen in the river waters of Japan which contain very little calcium bicarbonate.

On the other hand, 15.5 ppm in Lake Nong Han, 15.8 ppm in the Sai Buri River in the Malay peninsula, 16.0 ppm in the Chantaburi River on the east coast, 17.7 ppm in the Bang Pakong River (at Chachoengsao) are some of the examples of waters with short content.

The geographical distribution of alkalinity in Thailand shows, as indicated in Fig. 8, that the rivers in the basins of the Mae Nam Chao Phraya and the Mae Klong River abound in alkalinity while the east coast of Thailand, the Malay peninsula and the Korat Plateau area contain less, thus corresponding roughly with the distribution of Ca shown in Fig. 2.

The average content of HCO_3 of 30 places in Thailand is 82.6 ppm and as will be stated later, alkalinity is very high compared with 32.3 ppm for the Japanese average.

(g) *Sulfate.*

The city water of Bangkok shows a value of 36.3 ppm in the average during one year which is extremely high compared with other waters. In addition to this, the highest value during the year was 75.0 ppm on August 15, 1957 which happened to be in the rainy season while the lowest was 18. 5 ppm on January 15, 1958 which was during the dry season. Thus the rainy season means high content while the dry season means low content. This phe-

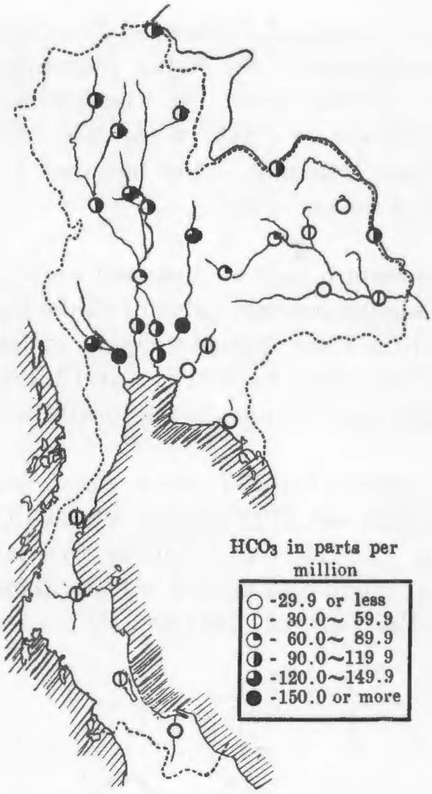


Fig. 8. Distribution of alkalinity. (Average value during one year.)

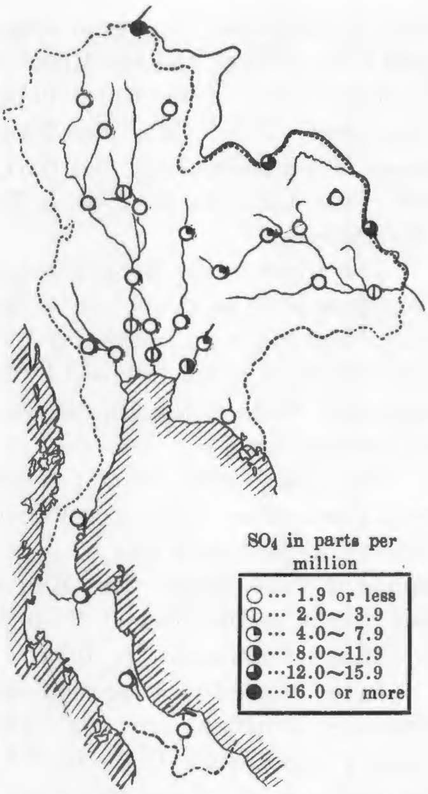


Fig. 9. Distribution of sulfate content. (Average value during one year.)

nomenon is in direct opposition to those of other constituents. This irregularity may probably be attributed to the artificial treatment to clarify the water by addition of sulfate.

With the exception of the city water of Bangkok, SO_4 contained in the Mae Khong River at Chiengsan, the northern most town in Thailand, is the highest. The average during a year was 17.1 ppm, the peak being 30.1 ppm on May 15, 1957 and the lowest being 8.3 ppm on September 15, 1956. Thus the seasonal change extends to a scope amounting to almost 4 times.

However, the content of SO_4 in the water of the Mae Khong River decreases to 14.7 ppm if we go down stream to Nongkai near the opposite side of Vientiane, the capital of Laos. If we go still down stream to Mukdaharn on the opposite side of Savannakhet in the territory of Laos it still decreases to 12.2 ppm. Thus there is a tendency of the density becoming gradually lower as the water continues to flow downstream. This fact makes us presume that the SO_4 content in the tributaries joining with the main stream in between is lower than that of the main stream of the Mae Khong.

Except the above-mentioned main stream of the Mae Khong River all waters at other 27 places contain less than 10.0 ppm. Among them, waters of Lake Nong Han, the second largest lake in Thailand, the basins of the Mae Nam Chao Phraya and the River Mae Klong, and of the Malay peninsula, the eastern part of the Korat Plateau etc. in other words the Rivers Phao, Chantaburi, Ping, Nan, Mae Nam Chao Phraya, Pa Sak, Kwae Noi, Mae Klong, Chumphon, Tapi, Sai Buri, and Lake Talesaab—show less than 1.0 ppm. The distribution of SO_4 in Thailand is shown in Fig. 9.

(h) *Chloride.*

The rivers in the Korat Plateau in the eastern part of Thailand contain abundance of Cl as in the case of Na. The highest average value of Cl during a year was 94.5 ppm in the Chi River at Kon Khen located roughly in the center of the Plateau followed by 61.6 and 56.6 ppm respectively at Ubolrajatani and Surin in the Mun River. In addition, 35.5 ppm in the Phao River was rather high.

The change of Cl content during one year in the Chi River which has the highest value is shown in Fig. 5. The peak was 312.5 ppm on March 15, 1957 while the lowest was 4.7 ppm on June 15, 1957 thus showing seasonal change of wide range. The Mun River at Surin also showed a remarkable change such as the peak of 261.0 ppm on February 20, 1957 and the lowest of 23.1 ppm on August 20, 1956.

In the areas other than the Korat Plateau it is noticed that the water of the Bang Pakong River (at Chachoengsao) is influenced by the infiltration of sea water only in the dry season when the water level is low while there are times when Lake Talesaab in the Malay peninsula is infiltrated by sea water. Cl content of these two waters reached about 5 g/l at the peak indicating that about 1/4 of the water is sea water.

The Cl content in the city water of Bangkok showed 23.0 ppm at the peak, 4.9 ppm at the lowest and 15.0 ppm in the average during the year. These figures are higher than 7.5 ppm in the average during the year in the lower stream of the Mae Nam Chao Phraya at Ayuthaya and 11.1 ppm at Nonburi in the same river.

The distribution of the Cl content in 28 rivers and 2 lakes is shown in Fig. 10. It shows that there is a ten-

Fig. 10. Distribution of chloride content. (Average value during one year.)

dency of scarcity in the upper and middle basins of the Mae Nam Chao Phraya, the basin of the Mae Klong River, the Malay peninsula, etc. Among them, Cl content of the three rivers of Ping, Yom and Wang was only 0.5—0.8 ppm.

(i) *Silica.*

SiO_2 in the water is well absorbed by rice increasing SiO_2 content in straws and leaves. This has the effect of strengthening the resisting power against rice-blast (Kobayashi 1954: Nishikado, Kobayashi, Inouye and Moritsugu 1955). Thus SiO_2 is a valuable element in growing rice.

However, SiO_2 content in Thailand is within the range of 6.3—23.7 ppm and the difference between rivers is not so marked as in other components. The geographical distribution is shown in Fig. 11 which indicates the tendency that the rivers in the basin of the Mae Nam Chao Phraya abound in silica and the rivers in the Korat Plateau, the east coast of Thailand and the Malay peninsula contain less. 23.7 ppm of the Pa Sak River (at Petchabun), 23.6 ppm of the Ping River (at Chiengmai), 22.0 ppm of the Wang River (at Lampang), 21.2 ppm of the Ping River (at Tak), 21.1 ppm of the Yom River, 20.3 ppm of the Nan River, 21.3 ppm of the Chumphon River in the Malay peninsula etc. are examples of more than 20.0 ppm while 6.3 ppm of Lake Nong Han, 10.1 ppm of the Chi River (at Kon Khen), 11.3 ppm of the Chi River (at Chaiyaphum), 10.8 ppm of the Mun River (at Ubolrajatani), 10.5 ppm of the Bang Pakong River (at Chachoengsao) etc. are examples of low contents.

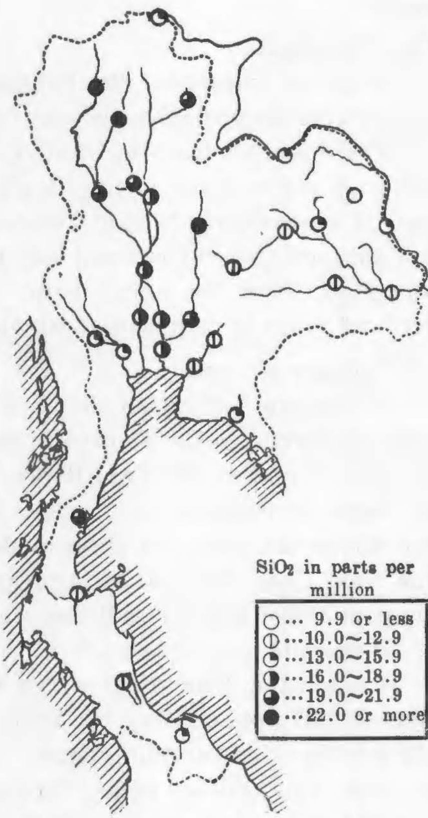


Fig. 11. Distribution of silica content. (Average value during one year.)

(j) *Iron.*

It is natural that Fe is contained in the clay or silt physically carried by the river water. Especially on account of the Thai rivers flowing through red soil common in the tropical zone, cases of the river waters becoming turbid in red color due to the existence of ferric oxide are frequently noticed. However, the content of Fe dissolved in solution in the transparent waters which are obtained after keeping the samples still or being centrifuged is unexpectedly small.

0.34 ppm in the Mun River (at Surin), 0.21 ppm in the Bang Pakong River, 0.12 ppm in Lake Nong Han, 0.11 ppm in the Mun River (at Ubolrajatani) etc. are examples of high content while about the half of the rivers investigated showed only 0.00—0.01 ppm in the average content during one year.

(k) *Phosphate.*

PO_4 is an important element both as fertilizer component for agricultural products and as nutritive element for plankton in the water.

There is a tendency of Thai rivers showing scarcity in quantity of phosphate. 30 places from among 31 places investigated showed only 0.00—0.01 ppm. It is considered that PO_4 content is scarce due to the fact that the rivers flow through tropical red soil containing abundance of iron. Therefore I resume that, from the agricultural point of view the necessity of phosphate fertilizer must be emphasized especially in Thailand.

(l) *Nitrate nitrogen.*

It is contained within the limit of 0.01—0.44 ppm. 0.44 ppm in the Mun River (at Surin) in the Korat Plateau is the highest followed by dense examples of 0.30 ppm in the Tapi River in the Malay peninsula, 0.20 ppm in the city water of Bangkok etc., while the Mae Khong River (at Chiengsan), the Nan River (at Nan and Pitsanuloke), the Yom River (at Sukhothai), the Mae Nam Chao Phraya (at Ayuthaya and Nonburi), the Wang River (at Lampang), the Kwae Noi River, the Chumphon River, the Sai Buri River etc. show 0.03 ppm or less.

Though the Mun River which is the highest showed a remarkably high value of 2.37 ppm on May 17, 1957 at the peak, it fluctuated between 0.00—0.71 ppm in other sampling times. Especially it reached 0.00 ppm on August 20, 1956. On the other hand, the Tapi River recorded 1.53 ppm on November 15, 1956 at its peak, but dropped to 0.00 ppm on August 15 and October 15, 1956.

As shown above, there was a tendency that NO_3-N varied very much depending on the time of sampling having no relation with other constituents.

(m) *Ammonia nitrogen.*

The highest is 0.19 ppm in the Mun River (at Surin). Excepting this, other rivers are within the limit of 0.03—0.10 ppm. Among these rivers, those containing comparatively high are the Bang Pakong River, the Prachin River and the Mae Nam Chao Phraya (at Nonburi).

(n) *Albuminoid nitrogen.*

This is organic nitrogen, easily decomposed into ammonia when boiled with alkaline potassium permanganate solution and is a useful component for agriculture along with nitrate and ammonia nitrogen. 0.26 ppm in the Mun River (at Surin), 0.24 ppm in the Nan River (at Pitsanuloke), 0.21 ppm in the Yom River (at Sukhothai), 0.20 ppm in the Pa Sak River and the Chi

River (at Chaiyaphum) etc. are examples of high values over 0.20 ppm. Other rivers have also the tendency of containing abundance compared with Japan where suspended solids are scarce.

(o) *Potassium permanganate consumed.*

The amount of $KMnO_4$ consumed is comparatively large in the Nan River (at Pitsanuloke), the Yom River (at Sukhothai), Tapi River etc. while the Chantaburi River, the Mae Khong River (at Mukdaharn), the Mae Klong River, the Chumphon River etc. show less. It is recognized that generally speaking the rivers in Thailand have the tendency to contain abundance of organic matters compared with Japan where the river waters are clear and transparent.

(p) *Dissolved solids.*

The most dense example is the Chi River (at Kon Khen) which contains abundance of sodium chloride showing an average value during the year of 244.7 ppm. Next comes 182.3 ppm in the Pa Sak River (at Saraburi) which is greatly affected by limestone. As for others, the city water of Bangkok, the Mun River (at Ubolrajatani), the Mae Klong River, the Mae Khong River (at Chiengsan), the Pa Sak River (at Petchabun), the Yom River (at Sukhothai) etc. showed abundance of dissolved solids or dense nature of water.

On the other hand, 35.3 ppm in the Sai Buri River in the Malay peninsula, 36.5 ppm in the Chantaburi River in the east coast of Thailand, 51.1 ppm in Lake Nong Han, 60.0 ppm in the Bang Pakong River (at Chachoengsao) etc. showed scarcity.

The geographical distribution of dissolved solids in Thailand is shown in Fig. 12.

(q) *Suspended solids.*

The amount of suspended solids usually differs very much between the flood season and the dry season. Those which showed abundance of average values during the year were 330.3 ppm in the Nan River (at Pitsanuloke), 296.8 ppm in the Yom River (at Sukhothai), 228.9 ppm in the Wang River, 217.3 ppm in the Pa Sak River (at Petchabun) etc., and generally speaking the main stream and tributaries of the Mae Nam Chao Phraya, the main stream of the Mae Khong River and the upper stream regions of the Chi and Mun rivers in the Korat Plateau have abundance.

The waters containing little suspended solids are 13.9 ppm in Lake Talesaab, 19.0 ppm in the Chumphon River, 31.3 ppm in the Sai Buri River, 27.8 ppm in the Chantaburi River on the east coast, etc.

The distribution of suspended solids in Thailand is shown in Fig. 13.

The Nan River which contains most suspended solids (at Pitsanuloke) showed 28.8 ppm on December 15, 1956 in the dry season while it increased to 1,436.4 ppm on May 15, 1957 thus indicating a very wide change.

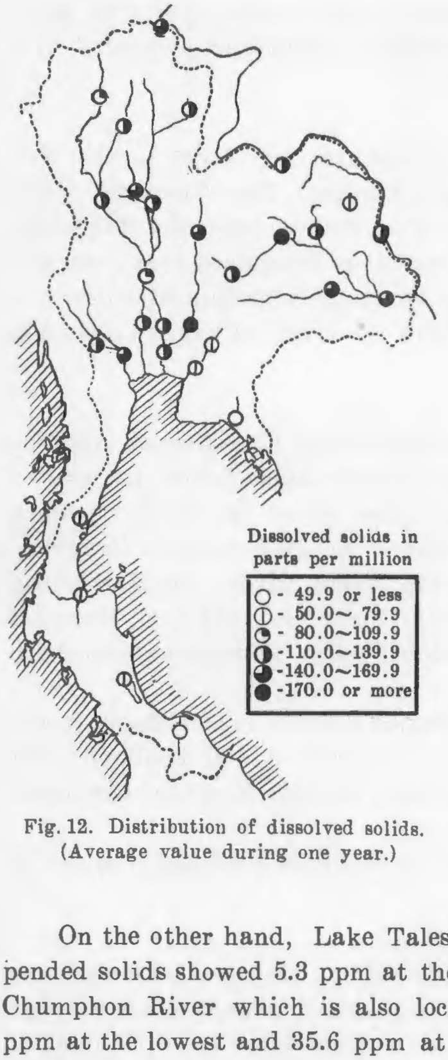


Fig. 12. Distribution of dissolved solids. (Average value during one year.)

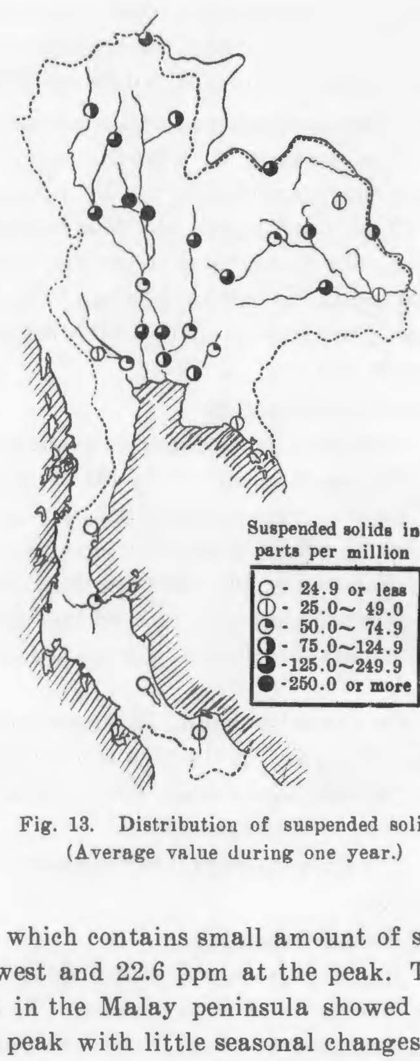


Fig. 13. Distribution of suspended solids. (Average value during one year.)

On the other hand, Lake Talesaab which contains small amount of suspended solids showed 5.3 ppm at the lowest and 22.6 ppm at the peak. The Chumphon River which is also located in the Malay peninsula showed 4.4 ppm at the lowest and 35.6 ppm at the peak with little seasonal changes in both cases.

It is noticeable that the waters of Thailand are high in turbidity and contain abundance of suspended solids as a general tendency when compared with Japan.

(r) *Turbidity.*

Turbidity is shown by the unit of intensity of light scattered by turbid water containing 1 part per million of Kaolin.

The highest average turbidity during the year was 459.1 of the Nan River (at Pitsanuloke) which contains abundance of suspended solids followed by 327.5 in the Wang River (at Lampang). Also, 255.0 in the Yom River (at Sukhothai), 202.8 in the Pa Sak River (at Petchabun), 195.2 in the Nan River (at Nan), 182.8 in the Mun River (at Surin), 177.6 in the Mae Nam

Chao Phraya (at Ayuthaya) etc. showed high turbidity as in the case of suspended solids. On the other hand the waters with low turbidity are 7.4 in Lake Talesaab, 8.0 in the Chumphon River, 8.9 in the Kwae Noi River, 10.5 in the Sai Buri River, 11.8 in the Tapi River etc. not to speak of 4.2 in the city water of Bangkok. Generally speaking the waters in the Malay peninsula are clear and transparent.

(s) *Hardness.*

Parts per million as $CaCO_3$ are calculated from the content of Ca and Mg. The highest value of hardness is 137.0 ppm in the Pa Sak River (at Saraburi) which contains most Ca. 129.5 ppm in the Mae Klong River, 116.9 ppm in the Kwae Noi River (at Kanchanaburi), 104.5 ppm in the Mae Khong River (at Chiengsan), 103.7 ppm in the Yom River (at Sukhothai), 101.0 ppm in the Mae Khong River (at Nongkai) etc. show values higher than 100 ppm.

On the other hand, 7.6 ppm in the Chantaburi River, 8.1 ppm in the Sai Buri River, 10.4 ppm in Lake Nong Han, 13.9 ppm in the Bang Pakong River etc. are low ones.

The range of differences between rivers of high values and those of low values is indeed great.

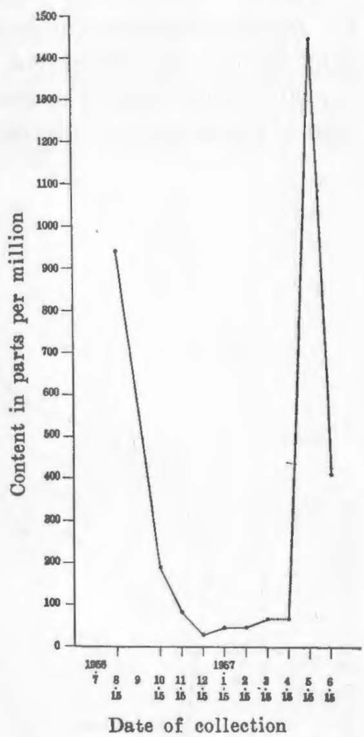


Fig. 14. Change of suspended solids in the Nan River during one year at Pitsanuloke.

V. CHARACTERISTICS OF THE MAIN STREAM OF THE MAE KHONG RIVER

The Mae Khong River originates from Tibet in China and flows down to the southern tip of the Indo-China peninsula. The total length of the flow is 4,200 km ranking second in length in southeastern Asia next to the Yantse River. It flows in the territories of five countries. The area of its basin amounts to 800,000 km^2, being almost 2 times the whole area of Japan. Thus the Mae Khong River is an important river for Thailand, Laos, Cambodia, Viet Nam etc. Its development program is attracting international interest.

As for this main stream of the Mae Khong River, I have chosen 3 places of sampling namely, Chiengsan, the northern-most town in Thailand, Nongkai in the Thai territory near Vientiane, the capital of Laos and Mukdaharn located on the opposite side of Savannakhet in the Laos territory in the lower stream region of the River.

Characteristics of the Mae Khong River can be found if the nature of waters at these 3 places are compared with the total average of the analytical results of 28 rivers and 2 lakes in Thailand as shown in the bottom part of Table 2. It has the tendency of containing abundance of Ca, Mg, alkalinity, dissolved solids, suspended solids etc. as well as remarkably abundant SO_4. On the other hand, Na, K and Cl are scarce compared with the averages for 30 places. Also it is one of the characteristics of the Mae Khong River that it shows almost neutral reaction as indicated in pH 6.9 inspite of the fact that other rivers clearly show weak acid.

The above is the characteristics of the Mae Khong River as compared with other waters in Thailand.

However, when comparison is made between the three places investigated, there is a tendency of Ca, Mg, Na, K, alkalinity, SO_4, dissolved solids etc. getting gradually dilute as the water flows down-stream.

In other words, Ca decreased from 32.1 to 26.8 ppm : HCO_3 from 116.9 to 100.3 ppm : SO_4 from 17.1 to 12.2 ppm : dissolved solids from 145.3 to 124.3 ppm. This may be due to the scarcity of these components in the waters of branch rivers joining with the main stream. In addition, a tendency was noticed that along with the gradual dilution of dissolved salts, suspended solids decreased from 186.2 to 99.9 ppm and the turbidity decreased from 145.1 to 57.1 thus the water becoming clearer as it flowed down along Thai frontier.

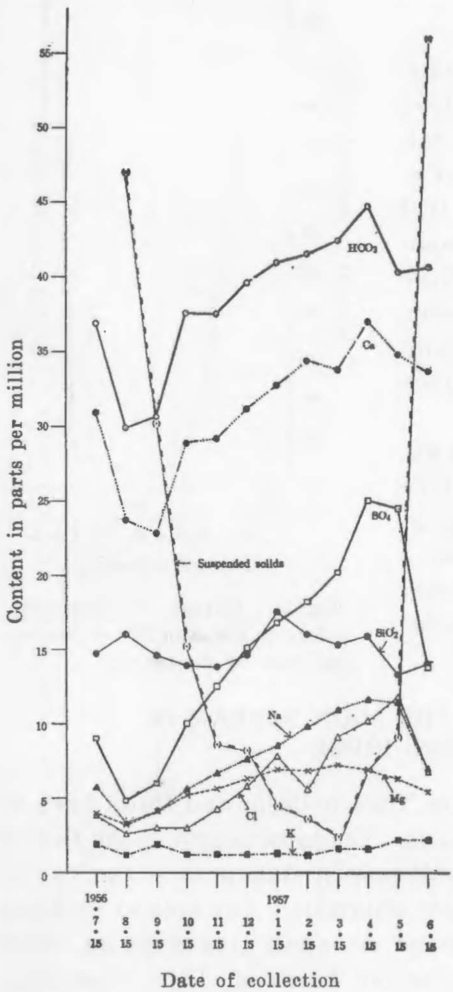


Fig. 15. Change of the quality of water in the Mae Khong River during one year at Nongkai.

Content of HCO_3 : scale 1/3

Content of suspended solids : scale 1/10

(a) *Seasonal change of the Mae Khong River.*

The change of the nature of water during the year of the Mae Khong River at Nongkai is shown in Fig. 15. Suspended solids showed 558.9 ppm on June 15, 1957 at the peak and it was high during the period from June to October. In other words abundance of clay and silt are being physically carried by the water during this period. However, during the low water level period from December to April, suspended solids became scarcer showing 24.0 ppm on March 15, 1957 at the lowest.

On the other hand, the density of salts carried in solution was highest around April in the low water level period in direct opposition to suspended solids, and was lowest in the high water level period of August and September.

Ca was 37.0 ppm at the peak and 22.8 ppm at the lowest; HCO_3 was 134.2 ppm at the peak and 89.6 ppm at the lowest; SO_4 was 25.0 ppm at the peak and 4.8 ppm at the lowest and Cl was 11.8 ppm at the peak and 2.6 ppm at the lowest.

A comparison of seasonal change between constituents showed the order of SO_4, Cl, Na$>$Mg, Ca, $HCO_3$$>$$SiO_2$ and changes of SO_4, Cl, and Na are most remarkable while the density of SiO_2 did not change very much during one year.

(b) *Quantity of mineral matter carried by the Mae Khong River in solution.*

The amount of mineral matter carried in solution by the water of the Mae Khong River at Nongkai located 1,500 km up-stream from the river mouth is calculated as follows:

According to the report of the U. N. Economic Commission for Asia and the Far East in Bangkok (1957) the annual average of the flow is 11,000 cubic meters per second as indicated by the result of the investigation of the discharge conducted at Phnom-Penh during the period from 1940 to 1951. Therefore, the amount of the flow in the Mae Khong River at Nongkai is roughly estimated at 4,700 cubic meters per second as calculated in the following manner.

$$A = A' \times \frac{B}{B'}$$

A' ······ the average discharge at Phnom-Penh

B ······ the area of the basin from the source to Nongkai (287,000 km^2.)

B' ······ the area of the basin from the source to Phnom-Penh (672,000 km^2.)

If 139.1 ppm (calculated from analytical results) which is the content of total dissolved mineral constituents at Nongkai is multiplied by this amount of flow, it shows that 0.65 tons of salts are flowing every second meaning 20,500,000 tons for one year. This amount corresponds to more than 16 times of 1,250,000 tons (Kobayashi 1955), the total amount of mineral matter carried in solution by the Tone River, the biggest river in Japan, for one year. On the other hand, if this amount is divided by 287,000 km^2. which is the area of the basin at Nongkai, the amount of mineral matter flowing out per 1 km^2. of land during one year is 71 tons. When compared with 80 tons, (Kobayashi, 1955) the amount of mineral matter carried out from 1 km^2. of land in solution by the Tone River, 220 tons (Kobayashi, not yet disclosed) of the Oyodo River in Miyazaki Prefecture which is located in the south-west of Japan and extremely rainy, etc., it is noticeable that the dissolution by the Mae Khong River is rather slow.

VI. CHARACTERISTICS OF THE RIVERS IN THE KORAT PLATEAU

Due to the topographical feature of the Korat Plateau which is high in the west and in the south and slopes down to the east, all rivers flow eastward into the Mae Khong River. The amount of rain in this area is scarce with the result that the amount of stream flow in the dry season decreases considerably.

I have chosen 6 places in all for my investigation, 2 places in the Chi River, 1 place in the Phao River, 1 place in the Mun River, 1 place in the lower stream of the joining point of the Chi and Mun rivers in addition to Lake Nong Han.

It is the characteristics of the rivers in the Korat Plateau that they contain abundance of Na and Cl during the dry season on account of the influence of the salt oozing out from the sandstone formation. Among the average amounts of content of Cl during one year at the 5 places thus chosen, 94.5 ppm in the Chi River (at Kon Khen) was the highest, while 16.8 ppm in the upper stream of the Chi River (at Chaiyaphum) was the lowest. On the other hand, among the highest values observed during the dry season, 312.5 ppm in the Chi River (at Kon Khen) and 261.0 ppm in the Mun River (at Surin) were by far the most abundant. Therefore, it is considered that the place where the rivers in the Korat Plateau are most affected by rock salt is located near Kon Khen and Surin. However, Cl content in Lake Nong Han located in the north-east corner of the Plateau showed 5.7 ppm at the lowest during one year and 13.7 ppm at the peak. Thus the effect of salt was not remarkable.

Another characteristics of waters in the Korat Plateau is the scarcity of Ca and alkalinity, i. e. influence of limestone. The content of Ca in Lake Nong Han is 3.0 ppm; that in the Phao River 9.0 ppm; that in the Mun River (at Surin) 10.6 ppm; that in the Mun River (at Ubolrajatani) 10.9 ppm. Thus the content is remarkably small compared with more or less 30 ppm in the Mae Khong River into which these waters flow.

(a) *Seasonal change of the Mun River.*

The waters in the northern half of the Korat Plateau flow into the Chi River and the waters in the southern half flow into the Mun River. These two rivers, after joining, flow eastward into the Mae Khong River. Fig. 16 shows the seasonal change of the nature of water at Ubolrajatani before flowing into the Mae Khong River.

Suspended solids abound in the three months of June, July and August of the rainy season and are scarce in the nine months from September to May in the following year, while dissolved solids are scare during the half year from July to December and are dense during the half year from January to June. Constituents in solution most markedly affected by seasonal change are Cl and Na. The highest values 126.3 and 86.8 ppm, respectively recorded of the two components on March 16, 1957 are about 20 times higher than the corresponding 5.2 and 4.5 ppm, the lowest values recorded on September 15, 1956.

On the other hand, Ca content and alkalinity showed the highest on April 16, 1957 and the lowest on July 15, 1956. The highest and the lowest values of Ca were respectively 19.5 ppm and 2.6 ppm and the highest and the lowest values of HCO_3 were respectively 74.3 ppm and 13.3 ppm. Therefore the change was not so remarkable as Na and Cl but still reached 6—7 times.

As stated above, the seasonal change of not only Na and Cl but also Ca and alkalinity in the rivers in the Korat Plateau was very remarkable compared with the rivers in other areas.

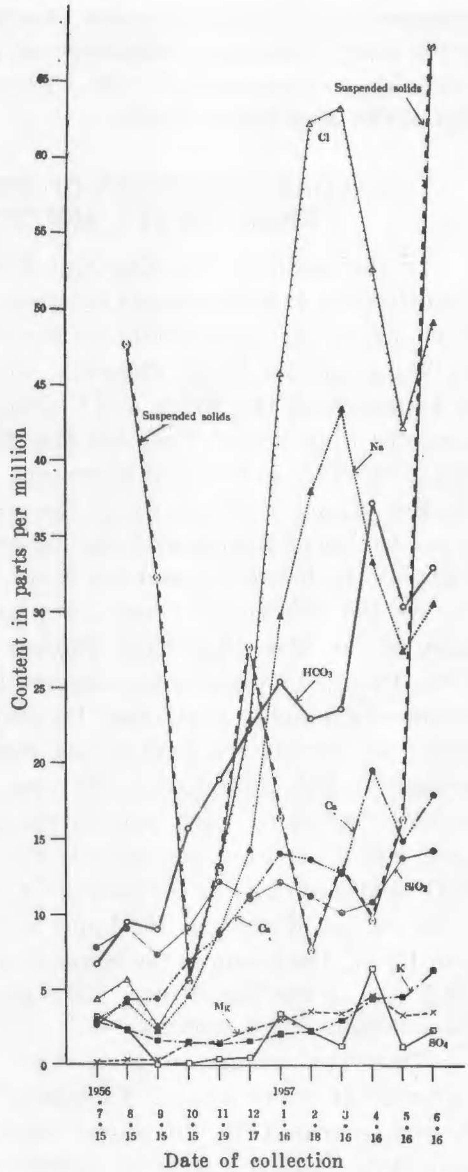


Fig. 16. Change of the quality of water in the Mun River during one year at Ubolrajatani.
Content of Na, HCO_3, Cl, and suspended solids : scale 1/2

However, it is a noteworthy fact that the times when Ca and alkalinity were highest and lowest did not correspond with the times when Na and Cl were highest and lowest. The cause for this phenomenon is considered to be either the difference of geographical distribution of rock-salt formations and limestone formations, or lack of uniformity in weather conditions.

In addition, the change of SiO_2 during the year was remarkably slow compared with other components, showing 7.3 ppm at the lowest and 14.3 ppm at the peak. Therefore, the scope of seasonal change between constituents was in the order of Na, Cl $>$ Ca, HCO_3 $>$ SiO_2. This is about the same with that of the Mae Khong River.

VII. CHARACTERISTICS OF THE BASINS OF THE MAE NAM CHAO PHRAYA AND THE MAE KLONG RIVER

In the basin of the Mae Nam Chao Phraya (commonly called the Mae Nam River in Japan) extends the great plain which is the principal producer of Thai rice. Its upper stream is separated into 4 rivers, the Nan, the Yom, the Wang and the Ping. Bangkok, the capital city of the country is located at the mouth of the River and Chiengmai, the second largest city is located along the Ping River. Thus the Mae Nam Chao Phraya meaning "The River that is Mother" is the most important river in Thailand. On the other hand, the Mae Klong River flows on the west side of the Mae Nam Chao Phraya on the border of Burma and the upper stream of the River is separated into 2 rivers, the Kwae Noi and the Kwae Yai.

As the objectives of my investigation, I have chosen 12 places in the basin of the Mae Nam Chao Phraya and 2 places in the basin of the Mae Klong River. 13 places from among the total of 14 places contain more than 20 ppm of Ca and in particular, Ca content of the Pa Sak River (at Saraburi) located in the eastern part of the Mae Nam Chao Phraya basin reached an average of 46.8 ppm during the year, thus ranking the highest among 31 places investigated. 37.7 ppm in the Mae Klong River and 33.8 ppm in the Kwae Noi River rank respectively the second and the third. The content of HCO_3 is also high as in the case of Ca. Headed by the two cases of 164.6 ppm in the Pa Sak River and 162.1 ppm in the Mae Klong River, 140.8 ppm in the Yom River, 138.7 ppm in the Kwae Noi River, 119.0 ppm in the Wang River, 105.5 ppm of the Nan River, 104.8 ppm of the Ping River, etc. are some of the noticeably high content.

Thus the waters in these two basins are very much affected by limestone at many places. Especially it is concluded that, as indicated in the spectrogram (Fig. 20) shown later, limestone or calcium carbonate not completely dissolved is being carried as suspended solids and as the result, the waters in the two basins of the Mae Nam Chao Phraya and the Mae Klong River have a great effect to neutralize the acidity of the soil when they are used as irrigation water for rice-growing.

The river waters in the basin of the Mae Nam Chao Phraya contain abundance of K, and 4.4 ppm which is the average of K content during one year at Uthai Thani in the middle stream and 4.3 ppm in the Supan River on the west part of the basin are the highest among 31 places investigated this time. The Wang River, the Ping River (at Tak), the Mae Nam Chao Phraya (at Ayuthaya and Nonburi), the Pa Sak River (at Petchabun) etc. show high content of more than 3 ppm.

On the other hand, only the Nan River in the north eastern corner of the Mae Nam Chao Phraya plain contains rather small quantity of K, and the content at Nan is only 1.1 ppm.

The content of SiO_2 in the basin of the Mae Nam Chao Phraya is more abundant than in other basins. Including 23.7 ppm in the Pa Sak River (at Petchabun) and 23.6 ppm in the Ping River (at Chiengmai), the Wang River, the Ping River (at Tak), the Nan River (at Nan), the Yom River etc. show contents over 20 ppm.

On the other hand, Mg content in the Mae Klong River and the Kwae Noi River which is the upper stream of the same river are the highest among the rivers in Thailand showing 8.6 ppm in the Mae Klong River and 8.0 ppm in the Kwae Noi River.

There is a tendency that the cotents of Cl and SO_4 in the basins of the Mae Nam Chao Phraya and the Mae Klong River are rather scarce, and the Cl content in the Ping River, the Wang River and the Yom River at 4 places of Chiengmai, Tak, Lampang and Sukhothai are respectively only 0.5, 0.7, 0.8 and 0.6 ppm.

(a) *Seasonal changes of the Mae Nam Chao Phraya and the Ping River.*

In order to clarify the changes of the nature of water during one year in the lower stream of the Mae Nam Chao Phraya and the Ping River which is the upper stream of the same river, the seasonal changes of these two rivers at Ayuthaya, the old capital and Chiengmai, a city in north Thailand are shown in Fig. 17 and Fig. 18.

Both rivers had abundance of suspended solids in the 4 months of June, July, August and September. Therefore, it is presumed that great amount of water flew during this period. On the other hand, suspended solids were comparatively scarce in the remaining 8 months with the result of less turbidity (Table 2).

However, dissolved salts were dilute in the 6 months from June to November while in the other 6 months they were dense.

The highest values of Ca and HCO_3 in the lower stream of the Mae Nam Chao Phraya were 33.5 ppm and 149.2 ppm respectively on May 15, 1957 being about 2.5 times greater in density compared with 13.6 and 58.8 ppm respectively at the lowest on August 15, 1956. 680.3 ppm which is the highest value of suspended solids in the same river, is over 80 times more abundant compared with 8.2 ppm at the lowest, while the quantity of Cl content shows a wide range of change indicating 22.5 ppm at the peak and 0.0 ppm at the lowest. On the other hand, the change of SiO_2 is within the range of 15.0 ppm at the lowest and 22.9 ppm at the peak thus showing extremely small seasonal changes.

The highest values of Ca and HCO_3 in the Ping River were respectively 32.1 ppm and 135.9 ppm on April 15, 1957 being about 4 times greater com-

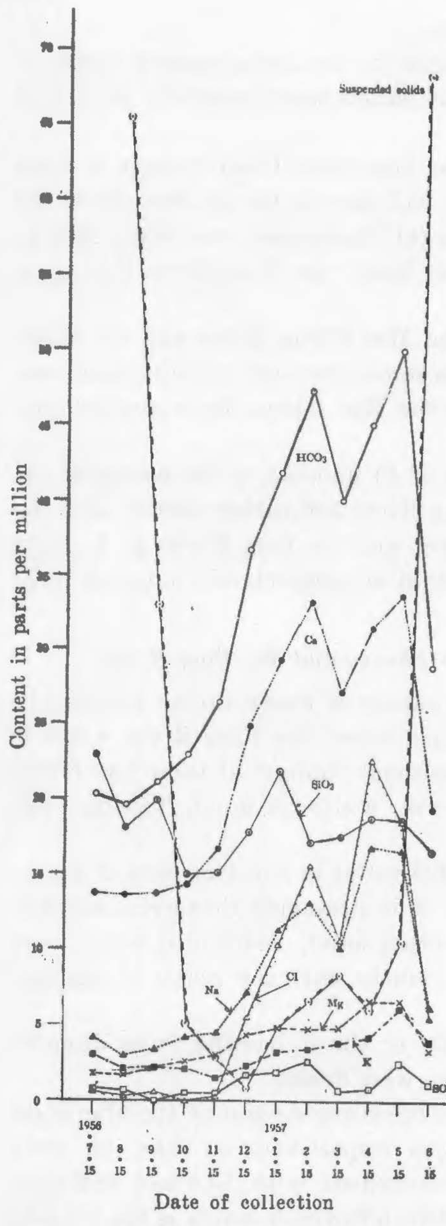


Fig. 17. Change of the quality of water in the Mae Nam Chao Phraya during one year at Ayuthaya.

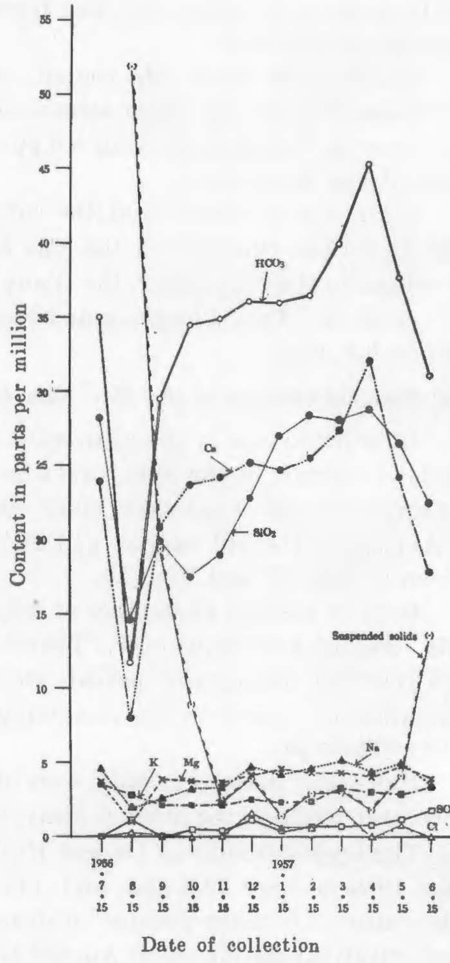


Fig. 18. Change of the quality of water in the Ping River during one year at Chiengmai.

Content of HCO_3: scale 1/3
Suspended solids: scale 1/10 in both figures.

pared with the lowest values of 8.0 ppm and 35.2 ppm respectively on August 15, 1956. However, excepting the two times of the highest and the lowest, Ca remained within the range of 17—27 ppm and HCO_3 remained within the range of 88—120 ppm throughout the other remaining 10 times of sampling thus showing less remarkable change. The quantity of Cl and SO_4 content in the Ping River during the year are always scarce showing a change of 0.0—1.9 ppm in the case of Cl and a change of 0.0—1.8 ppm in the case of SO_4. The change of Na is 2.0—5.2 ppm, that of K is 2.1—3.5 ppm and that of SiO_2 is 14.6—28.8 ppm thus all of them showing no remarkable seasonal changes.

VIII. CHARACTERISTICS OF THE WATERS IN THE MALAY PENINSULA AREA

I have chosen as the objectives of my investigation Lake Talesaab, the largest lake in Thailand and 3 other rivers. It has been found out that the waters in the peninsula contain small quantity of dissolved salts throughout the year without any distinction between dry and wet seasons due to the influence of the ocean weather accompanying abundance of rain.

Dissolved solids are lowest in the Sai Buri River in the southern most tip showing 35.3 ppm while the highest is 74.4 ppm in the Chumphon River in the north both being far lower than 115.2 ppm, the average figure for 30 places in Thailand as shown in the bottom part of Table 2.

The average contents of Ca and Mg in the Sai Buri River during one year are the same with those in the Chantaburi River which, being located on the east coast of Thailand is affected by the ocean weather in the same way showing 1.9 and 0.7 ppm respectively, the lowest figures among 31 places investigated. It is my opinion that the scarcity of salts in the Sai Buri River and the Chantaburi River is more accelerated on account of the influence of granite rock which is difficult to be permeated and dissolved. The quantity of Ca content in 3 other places outside of the Sai Buri River is 9.3—11.9 ppm being about a half in density compared with 19.8 ppm, the average figure in Thailand.

It is my opinion that outside of the meteorological reason that there is abundance of rain in the peninsula, scattered existence of the Korat series of geological formations (Thai Royal Department of Mines 1953) also contributes to the scarcity of Ca in the waters as in the case of the Korat Plateau.

The extreme scarcity of the content of SO_4 as anion is another characteristic of the waters in the peninsula showing only 0.0—0.4 ppm at 4 places. A tendency of extreme scarcity is noticed as in the case of the above mentioned Mae Klong, Ping, Nan, Mae Nam Chao Phraya (at Uthai Thani) Rivers etc.

The waters in the peninsula have the tendency to contain scarcity of not only dissolved salts but also of suspended solids. 13.9 ppm in Lake Talesaab, 19.0 ppm in the Chumphon River and 31.3 ppm of the Sai Buri River are scarcer compared with 112.0 ppm, the total average in Thailand. In addition, the turbidity at 4 places ranges 7.4—11.8 being extremely low compared with 111.6, the average in Thailand. Therefore, it is noticed that the waters are clear and transparent.

(a) *Seasonal changes of the Sai Buri River.*

The seasonal changes during one year of the Sai Buri River which, being located in the southern most part of Thailand, contains the least dissolved solids due to the ocean weather and the influence of granite rock are shown in Fig. 19.

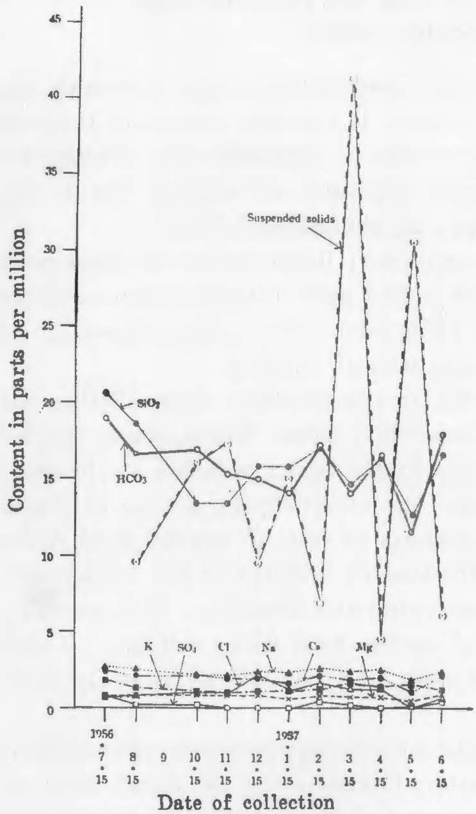


Fig. 19. Change of the quality of water during one year of the Sai Buri River. Content of suspended solids: scale 1/2

In Thailand except its coast areas, one year is distinctly divided into the dry season and the rainy season due to the influence of the monsoon. It is already shown in Fig. 15—18 that there is a tendency that salts in the waters become dense in the dry season and dilute in the rainy season.

However, the Sai Buri River in the peninsula showed no regular changes between the rainy and dry seasons. Suspended solids showed the highest value of 82.6 ppm on March 15, 1957 which corresponded to the dry season in other areas while it showed the lowest value of 8.9 ppm on April 15 which was one month later. Thus the increase or the decrease of the quantity not only had no relationship with the seasons but also showed a very narrow range in the change compared with the rivers in other areas. This was the same in the case of the changes of Ca and alkalinity. They were most concentrated on July 15, 1956 and most diluted on May 15, 1957. The highest value of Ca was 2.4 ppm while the lowest was 1.1 ppm. As for HCO_3, the highest value was 18.9 ppm while the lowest was 11.6 ppm. The periods in which these two constituents increased or decreased were not only entirely the opposite to those of the rivers in other areas, but also showed small ranges in the change. In addition, the contents of Mg, Na, K, SO_4 were also very scarce throughout the year. Especially the fact that in spite of its small size and its proximity to the ocean, the average content of Cl during one year in the Sai Buri River was only 1.1 ppm is considered to mean that the influence of the sea water carried by the wind is slight.

IX. SPECTROCHEMICAL ANALYSIS OF SUSPENDED SEDIMENT

In consideration of the possibility of cases in which the quantity of metalic elements contained in turbid substances may differ greatly due to the influence of geology, mineral ores, etc., the spectrogram of suspended solids filtered at each places of sampling photographed by QF—60 type spectrograph produced by Shimadzu Seisakusho Ltd. is shown in Fig. 20. It shows that the Pa Sak River (No. 22) and the Kwae Noi River (No. 25) contain extravagant quantity of Ca and the Mae Klong River (No. 26) also shows that tendency. Therefore, it has been found out that, as already stated, these 3 rivers not only contain the highest values of Ca dissolved in the water and alkalinity in Thailand but also calcium carbonate which is not dissolved is flowing in the form of solid objects. As a means of comparison the Takahashi River which flows near our Institute in Kurashiki City is indicated at the bottom of the spectrogram. This river is one of the examples of high lime rock influence among Japanese rivers, but the quantity of Ca contained in suspended solids is not remarkable as will be seen from the spectrogram.

Tin which is the representative mineral resource in Thailand is most detected in the suspended solids of the Kwae Noi River (No. 25) while silver is detected in the Tapi River (No. 28).

However, copper content in the corresponding Takahashi River is more abundant than that of any other river in Thailand.

X. COMPARISON OF THE QUALITY OF WATERS BETWEEN THAILAND AND JAPAN

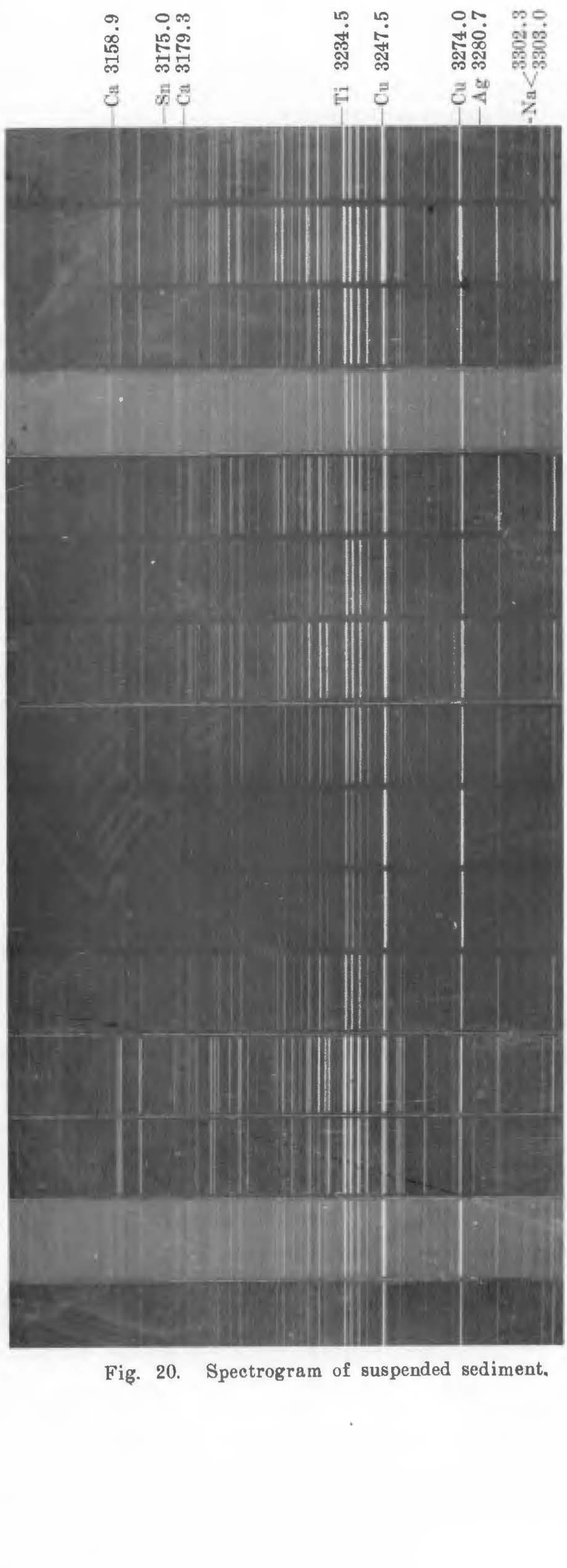
In order to ascertain difference of the nature of water in tropical Thailand and Japan which is a volcanic country surrounded by the sea, I have compared the nature of water in 334 sample waters taken at 30 places in Thailand (except the city water of Bangkok and waters mixed with sea water) with that of 3,239 sample waters taken from representative 382 rivers throughout the territory of Japan

The results are as follows :

(a) *Calcium.*

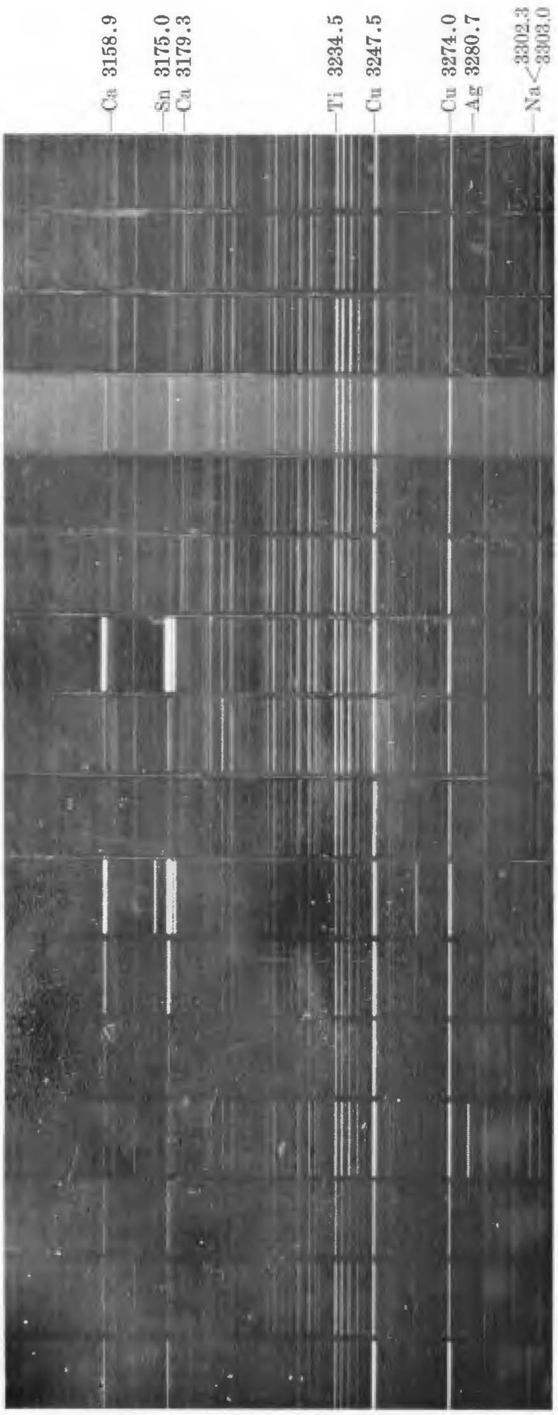
The relationship between the content of Ca and the number of waters (frequency) is shown in Table 3 and Fig. 21. According to these, the content in Thailand is very great compared with that of Japan.

62.8%, which is more than half, of the number of river waters in Japan contain less than 9.9 ppm while waters containing such scarce amount in Thailand are only 25.4% of the total. In addition, waters containing 20.0—29.9 ppm occupy 23.3% : those containing 30.0—39.9 ppm occupy 18.6% : and



No.	Name of river
1	Mae Khong River
2	Mae Khong River
3	Mae Khong River
4	Lake Nong Han
5	Chi River
6	Chi River
7	Phao River
8	Mun River
9	Mun River
10	Chantaburi River
11	Prachin River
12	Bang Pakong River
13	Ping River
14	Wang River
15	Ping River

Fig. 20. Spectrogram of suspended sediment.



No.	Name of river
16	Nan River
17	Nan River
18	Yom River
19	Mae Nam Chao Phraya
20	Mae Nam Chao Phraya
21	Pa Sak River
22	Pa Sak River
23	Mae Nam Chao Phraya
24	Supan River
25	Kwae Noi River
26	Mae Klong River
27	Chumphon River
28	Tapi River
29	Lake Talesaab
30	Sai Buri River
	Takahashi River at Kurashiki, Okayama Prefecture, Japan.

Fig. 20. Continued.

Table 3. Comparison of the relationship between the content of Ca and the number of river waters in Thailand and Japan.

Content in parts per million	Thailand		Japan	
	Number of river waters	Frequency %	Number of river waters	Frequency %
1.0~ 1.9	11	3.3	0	0
2.0~ 2.9	24	7.1	1	0.3
3.0~ 3.9	5	1.5	16	4.2
4.0~ 4.9	8	2.4	26	6.8
5.0~ 5.9	6	1.8	41	10.7
6.0~ 6.9	8	2.4	50	13.1
7.0~ 7.9	4	1.2	39	10.2
8.0~ 8.9	8	2.4	39	10.2
9.0~ 9.9	11	3.3	28	7.3
Sub total	85	25.4	240	62.8
10.0~10.9	5	1.5	29	7.6
11.0~11.9	11	3.3	21	5.5
12.0~12.9	16	4.8	16	4.2
13.0~13.9	11	3.3	19	4.9
14.0~14.9	7	2.1	16	4.2
15.0~15.9	7	2.1	5	1.3
16.0~16.9	7	2.1	7	1.8
17.0~17.9	9	2.7	7	1.8
18.0~18.9	8	2.4	2	0.5
19.0~19.9	6	1.8	1	0.3
Sub total	87	26.1	123	32.1
20.0~20.9	3	0.9	4	1.0
21.0~21.9	7	2.1	8	2.1
22.0~22.9	5	1.5	2	0.5
23.0~23.9	9	2.7	1	0.3
24.0~24.9	14	4.1	0	0
25.0~25.9	8	2.4	0	0
26.0~26.9	6	1.8	1	0.3
27.0~27.9	11	3.3	1	0.3
28.0~28.9	6	1.8	0	0
29.0~29.9	9	2.7	0	0
Sub total	78	23.3	17	4.5

Content in parts per million	Thailand		Japan	
	Number of river waters	Frequency %	Number of river waters	Frequency %
30.0~30.9	13	3.9	0	0
31.0~31.9	8	2.4	0	0
32.0~32.9	7	2.1	0	0
33.0~33.9	9	2.7	1	0.3
34.0~34.9	7	2.1	0	0
35.0~35.9	2	0.6	1	0.3
36.0~36.9	4	1.2	0	0
37.0~37.9	6	1.8	0	0
38.0~38.9	5	1.5	0	0
39.0~39.9	1	0.3	0	0
Sub total	62	18.6	2	0.6
40.0~40.9	3	0.9	0	0
41.0~41.9	1	0.3	0	0
42.0~42.9	1	0.3	0	0
43.0~43.9	0	0	0	0
44.0~44.9	3	0.9	0	0
45.0~45.9	3	0.9	0	0
46.0~46.9	1	0.3	0	0
47.0~47.9	0	0	0	0
48.0~48.9	2	0.6	0	0
49.0~49.9	1	0.3	0	0
50.0~54.9	0	0	0	0
55.0~59.9	3	0.9	0	0
60.0~64.9	1	0.3	0	0
65.0~69.9	0	0	0	0
70.0~74.9	3	0.9	0	0
Sub total	22	6.6	0	0
Grand total	334	100.0	382	100.0

those containing more than 40.0 ppm occupy up to 6.6%. In total, waters containing more than 20.0 ppm amount to 48.5%, almost the half, while in Japan waters containing high amount of 20.0 ppm or more occupy only 5.1% in all.

The total average of the quantity of Ca contained in Japanese river waters investigated by myself is 9.5 ppm while that of Thailand is 19.8 ppm

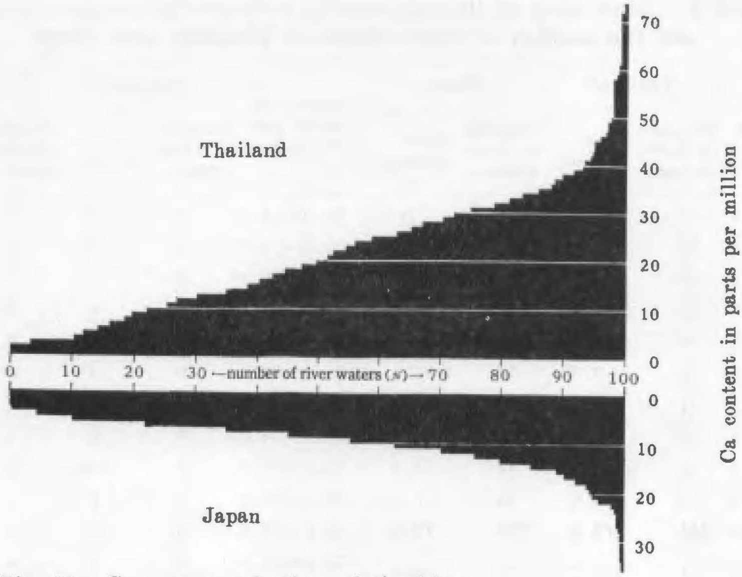


Fig. 21. Comparison of the relationship between the content of Ca and the number of river waters in Thailand and Japan.

as indicated in the bottom of Table 2 showing a density about 2 times as large as that of Japan.

Therefore, as will be made clearer by the comparison of alkalinity appearing later, the influence of lime rock on river waters is far greater in Thailand than in Japan.

(b) *Sodium.*

The comparison between the two countries is shown in Table 4 and Fig. 22.

The number of river waters containing less than 9.9 ppm in the amount of Na content occupy 72.9% in Japan while it was 73.0% in Thailand thus showing practically no difference between the two countries. As for waters containing 10.0—19.9 ppm, they occupy 21.8% in Japan while the percentage in Thailand is 19.2% thus showing practically the same frequency. On the other hand, if comparison is made concerning waters having high density of more than 40.0 ppm, the percentage in Japan is 0.9% while that of Thailand is 4.5% thus showing the existence of more rivers of this kind. The reason for this phenomenon is nothing but the scattered existence in the Korat Plateau of rivers having abundance of Na due to the influence of rock salt formations. Thus it can be seen that, though the total average of the amount of Na contained in the river waters is 6.8 ppm in Japan as against 10.7 ppm in Thailand, if the figures are calculated excepting the peculiar rivers in the Korat Plateau, the average for Thailand becomes 6.0 ppm thus showing that the content is more in Japan.

Table 4. Comparion of the relationship between the content of Na and the number of river waters in Thailand and Japan.

Content in parts per million	Thailand		Japan		Content in parts per million	Thailand		Japan	
	Number of river waters	Frequency %	Number of river waters	Frequency %		Number of river waters	Frequency %	Number of river waters	Frequency %
0~ 0.9	1	0.3	0	0	24.0~24.9	1	0.3	0	0
1.0~ 1.9	17	5.1	0	0	25.0~25.9	1	0.3	1	0.3
2.0~ 2.9	30	9.0	3	0.8	26.0~26.9	0	0	1	0.3
3.0~ 3.9	37	11.0	11	2.9	27.0~27.9	0	0	0	0
4.0~ 4.9	49	14.6	30	7.8	28.0~28.9	2	0.6	0	0
5.0~ 5.9	31	9.3	54	14.1	29.0~29.9	0	0	0	0
6.0~ 6.9	27	8.1	53	13.8	30.0~30.9	0	0	3	0.8
7.0~ 7.9	25	7.5	45	11.8	31.0~31.9	0	0	1	0.3
8.0~ 8.9	15	4.5	57	14.9	32.0~32.9	1	0.3	1	0.3
9.0~ 9.9	12	3.6	26	6.8	33.0~33.9	0	0	0	0
Sub total	**244**	**73.0**	**279**	**72.9**	34.0~34.9	0	0	1	0.3
10.0~10.9	14	4.2	25	6.5	35.0~35.9	0	0	0	0
11.0~11.9	14	4.2	13	3.4	36.0~36.9	1	0.3	1	0.3
12.0~12.9	9	2.7	19	5.0	37.0~37.9	1	0.3	0	0
13.0~13.9	6	1.8	7	1.8	38.0~38.9	1	0.3	0	0
14.0~14.9	3	0.9	4	1.0	39.0~39.9	1	0.3	0	0
15.0~15.9	6	1.8	4	1.0	**Sub total**	**11**	**3.3**	**16**	**4.4**
16.0~16.9	4	1.2	6	1.6	40.0~49.9	3	0.9	0	0
17.0~17.9	6	1.8	2	0.5	50.0~59.9	3	0.9	1	0.3
18.0~18.9	2	0.6	2	0.5	60.0~69.9	2	0.6	1	0.3
19.0~19.9	0	0	2	0.5	70.0~79.9	2	0.6	0	0
Sub total	**64**	**19.2**	**84**	**21.8**	80.0~89.9	2	0.6	0	0
20.0~20.9	1	0.3	2	0.5	90.0~99.9	0	0	0	0
21.0~21.9	0	0	2	0.5	100.0~199.9	3	0.9	1	0.3
22.0~22.9	0	0	2	0.5	**Sub total**	**15**	**4.5**	**3**	**0.9**
23.0~23.9	1	0.3	1	0.3	**Grand total**	**334**	**100.0**	**382**	**100.0**

(c) *Potassium.*

The amount of K which is an important constituent for fertilizer is remarkably abundant in Thailand. As is shown in Table 5 and Fig. 23, 42.9% of the river waters in Japan contain less than 0.99 ppm of K while only 6.2% of the river waters in Thailand contain such scarce amount. In addition, in Thailand, waters containing 2.00—2.99 ppm occupy 26.4% ; waters containing 3.00—4.99 ppm occupy 23.1% ; and waters containing a high density of more than 5.00 ppm occupy up to 7.5%. All in all, river waters containing more than 2.00 ppm occupy 57.0% showing more than half of the total.

On the other hand, river waters containing more than 2.00 ppm in Japan occupy only 13.1% in all.

While the total average of content in Japanese river is 1.3 ppm, the av-

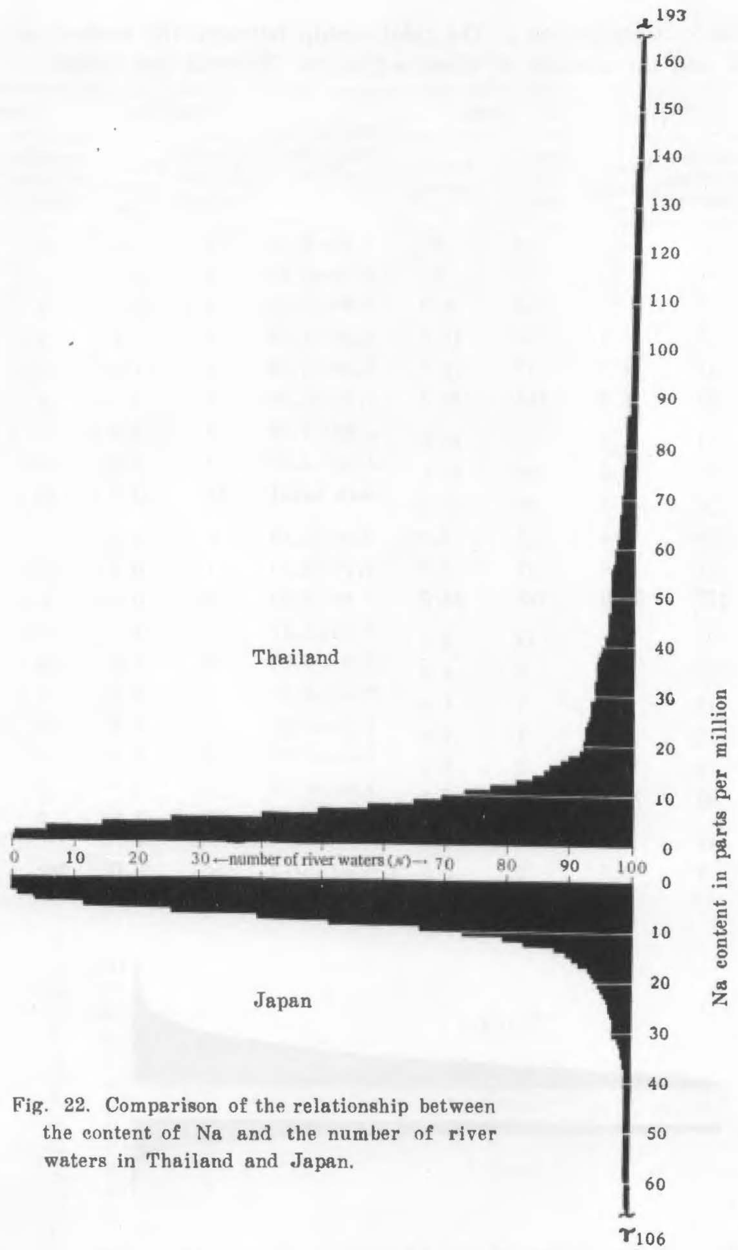


Fig. 22. Comparison of the relationship between the content of Na and the number of river waters in Thailand and Japan.

erage in Thailand is 2.5 ppm showing a density 2 times greater. Thus the waters in Thailand are advantageous from the point of view of agriculture in that they contain abundance of K.

The tendency that the ratio of K/Na is higher in Thailand than in Japan is also one of the differences between the rivers in the two countries.

(d) *Alkalinity.*

As in the case of Ca, alkalinity is remarkably abundant in Thailand. The

Table 5. Comparison of the relationship between the content of K and the number of river waters in Thailand and Japan.

Content in parts per million	Thailand		Japan		Content in parts per million	Thailand		Japan	
	Number of river waters	Frequency %	Number of river waters	Frequency %		Number of river waters	Frequency %	Number of river waters	Frequency %
0~0.19	0	0	0	0	3.40~3.59	12	3.6	0	0
0.20~0.39	0	0	0	0	3.60~3.79	10	3.0	1	0.3
0.40~0.59	0	0	23	6.0	3.80~3.99	8	2.4	1	0.3
0.60~0.79	5	1.5	68	17.8	4.00~4.19	8	2.4	4	1.0
0.80~0.99	16	4.7	73	19.1	4.20~4.39	6	1.8	0	0
Sub total	**21**	**6.2**	**164**	**42.9**	4.40~4.59	6	1.8	0	0
1.00~1.19	21	6.3	65	17.0	4.60~4.79	3	0.9	1	0.3
1.20~1.39	29	8.6	48	12.6	4.80~4.99	3	0.9	0	0
1.40~1.59	24	7.2	25	6.5	**Sub total**	**77**	**23.1**	**13**	**3.4**
1.60~1.79	28	8.4	19	5.0	5.00~5.19	5	1.5	0	0
1.80~1.99	21	6.3	11	2.9	5.20~5.39	1	0.3	1	0.3
Sub total	**123**	**36.8**	**168**	**44.0**	5.40~5.59	2	0.6	0	0
2.00~2.19	24	7.2	13	3.4	5.60~5.79	4	1.2	0	0
2.20~2.39	28	8.4	9	2.4	5.80~5.99	3	0.9	0	0
2.40~2.59	12	3.6	7	1.8	6.00~6.99	5	1.5	1	0.3
2.60~2.79	12	3.6	4	1.0	7.00~7.99	1	0.3	0	0
2.80~2.99	12	3.6	2	0.5	8.00~8.99	2	0.6	0	0
Sub total	**88**	**26.4**	**35**	**9.1**	9.00~9.99	2	0.6	0	0
3.00~3.19	12	3.6	4	1.0	**Sub total**	**25**	**7.5**	**2**	**0.6**
3.20~3.39	9	2.7	2	0.5	**Grand total**	**334**	**100.0**	**382**	**100.0**

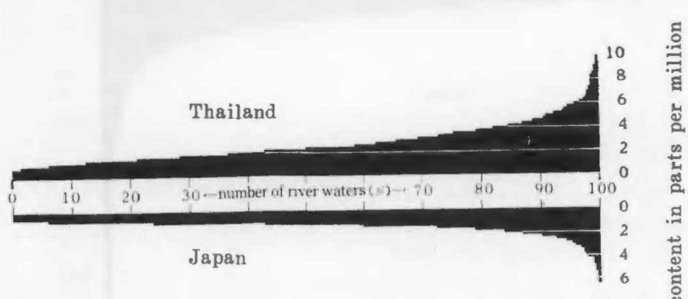


Fig. 23. Comparison of the relationship between the content of K and the number of river waters in Thailand and Japan.

comparison is shown in Table 6 and Fig. 24.

In Japan, river waters containing scarce amount of less than 49.9 ppm occupy 85.6%, a majority while rivers containing high density of more than 100.0 ppm occupy only 1.1%. In contrast to this, in Thailand, waters containing less than 49.9 ppm occupy 27.1% ; waters containing 100.0—149.9

Table 6. Comparion of the relationship between alkalinity (HCO_3) and the number of river waters in Thailand and Japan.

Alkalinity in parts per million	Thailand Number of river waters	Thailand Frequency %	Japan Number of river waters	Japan Frequency %
0 ~ 4.9	1	0.3	13	3.4
5.0~ 9.9	3	0.9	6	1.6
10.0~14.9	19	5.6	17	4.4
15.0~19.9	22	6.5	42	11.0
20.0~24.9	6	1.8	62	16.2
25.0~29.9	8	2.4	56	14.7
30.0~34.9	5	1.5	57	14.9
35.0~39.9	10	3.0	32	8.4
40.0~44.9	9	2.7	23	6.0
45.0~49.9	8	2.4	19	5.0
Sub total	**91**	**27.1**	**327**	**85.6**
50.0~54.9	10	3.0	17	4.4
55.0~59.9	18	5.4	15	3.9
60.0~64.9	17	5.1	5	1.3
65.0~69.9	9	2.7	6	1.6
70.0~74.9	7	2.1	7	1.8
75.0~79.9	10	3.0	1	0.3
80.0~84.9	10	3.0	0	0
85.0~89.9	6	1.8	0	0
90.0~94.9	9	2.7	0	0
95.0~99.9	5	1.5	0	0
Sub total	**101**	**30.3**	**51**	**13.3**
100.0~104.9	7	2.1	0	0
105.0~109.9	12	3.6	0	0
110.0~114.9	20	6.0	2	0.5
115.0~119.9	19	5.7	1	0.3
120.0~124.9	20	6.0	1	0.3
125.0~129.9	9	2.7	0	0
130.0~134.9	9	2.7	0	0
135.0~139.9	8	2.4	0	0
140.0~144.9	2	0.6	0	0
145.0~149.9	6	1.8	0	0
Sub total	**112**	**33.6**	**4**	**1.1**
150.0~154.9	3	0.9	0	0
155.0~159.9	2	0.6	0	0
160.0~164.9	5	1.5	0	0
165.0~169.9	3	0.9	0	0
170.0~174.9	3	0.9	0	0
175.0~179.9	1	0.3	0	0
180.0~184.9	3	0.9	0	0
185.0~189.9	0	0	0	0
190.0~194.9	0	0	0	0
195.0~199.9	1	0.3	0	0
200.0~249.9	8	2.4	0	0
250.0~299.9	1	0.3	0	0
Sub total	**30**	**9.0**	**0**	**0**
Grand total	**334**	**100.0**	**382**	**100.0**

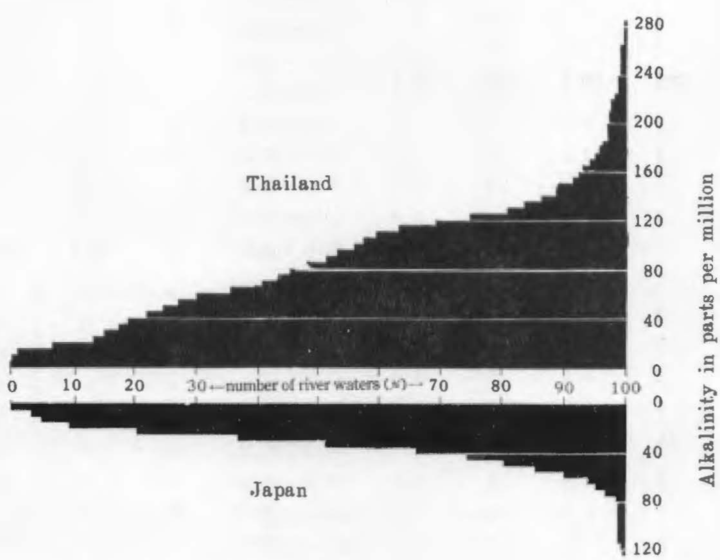


Fig. 24. Comparison of the relationship between alkalinity (HCO_3) and the number of river waters in Thailand and Japan.

ppm occupy 33.6%; and waters containing high density of more than 150.0 ppm occupy up to 9.0%. All in all, the number of river waters containing a density of more than 100.0 ppm totals 42.6%.

The average of HCO_3 content of 382 rivers in Japan is 32.3 ppm while the average of 30 rivers in Thailand is 82.6 ppm, about 2.5 times as high compared with that of Japan. Thus, as stated in the section of Ca, the influence of lime rock dissolved in the Thai rivers is far greater than that in Japan and the waters in Thailand have strong power to neutralize acidity.

(e) *Sulfate.*

Contrary to Ca and alkalinity, the content of SO_4 is remarkably abundant

Table 7. Comparison of the relationship between the content of SO_4 and the number of river waters in Thailand and Japan.

Content in parts per million	Thailand		Japan	
	Number of river waters	Frequency %	Number of river waters	Frequency %
0 ~ 0.9	182	54.4	0	0
1.0~ 1.9	38	11.4	17	4.5
2.0~ 2.9	15	4.5	25	6.5
3.0~ 3.9	21	6.3	44	11.5
4.0~ 4.9	9	2.7	38	9.9
5.0~ 5.9	9	2.7	28	7.3
6.0~ 6.9	5	1.5	22	5.8
7.0~ 7.9	4	1.2	17	4.5
8.0~ 8.9	7	2.1	25	6.5
9.0~ 9.9	5	1.5	12	3.2
Sub total	**295**	**88.3**	**228**	**59.7**
10.0~10.9	3	0.9	14	3.7
11.0~11.9	4	1.2	19	5.0
12.0~12.9	6	1.8	12	3.1
13.0~13.9	2	0.6	11	2.9
14.0~14.9	2	0.6	11	2.9
15.0~15.9	5	1.5	5	1.3
16.0~16.9	3	0.9	3	0.8
17.0~17.9	3	0.9	10	2.6
18.0~18.9	2	0.6	5	1.3
19.0~19.9	1	0.3	7	1.8
Sub total	**31**	**9.3**	**97**	**25.4**
20.0~20.9	2	0.6	6	1.5
21.0~21.9	1	0.3	3	0.8
22.0~22.9	0	0	1	0.3
23.0~23.9	0	0	2	0.5
24.0~24.9	2	0.6	3	0.8
25.0~25.9	1	0.3	1	0.3
26.0~26.9	0	0	1	0.3
27.0~27.9	0	0	2	0.5
28.0~28.9	1	0.3	1	0.3
29.0~29.9	0	0	3	0.8
Sub total	**7**	**2.1**	**23**	**6.1**
30.0~30.9	1	0.3	1	0.3
31.0~31.9	0	0	4	1.0
32.0~32.9	0	0	3	0.8
33.0~33.9	0	0	1	0.3
34.0~34.9	0	0	2	0.5
35.0~35.9	0	0	2	0.5
36.0~36.9	0	0	2	0.5
37.0~37.9	0	0	0	0
38.0~38.9	0	0	2	0.5
39.0~39.9	0	0	0	0
Sub total	**1**	**0.3**	**17**	**4.4**
40.0~49.9	0	0	2	0.5
50.0~59.9	0	0	0	0
60.0~69.9	0	0	4	1.0
70.0~79.9	0	0	2	0.5
80.0~89.9	0	0	3	0.8
90.0~99.9	0	0	1	0.3
100.0~149.9	0	0	2	0.5
150.0~199.9	0	0	2	0.5
200.0~249.9	0	0	0	0
250.0~299.9	0	0	1	0.3
Sub total	**0**	**0**	**17**	**4.4**
Grand total	**334**	**100.0**	**382**	**100.0**

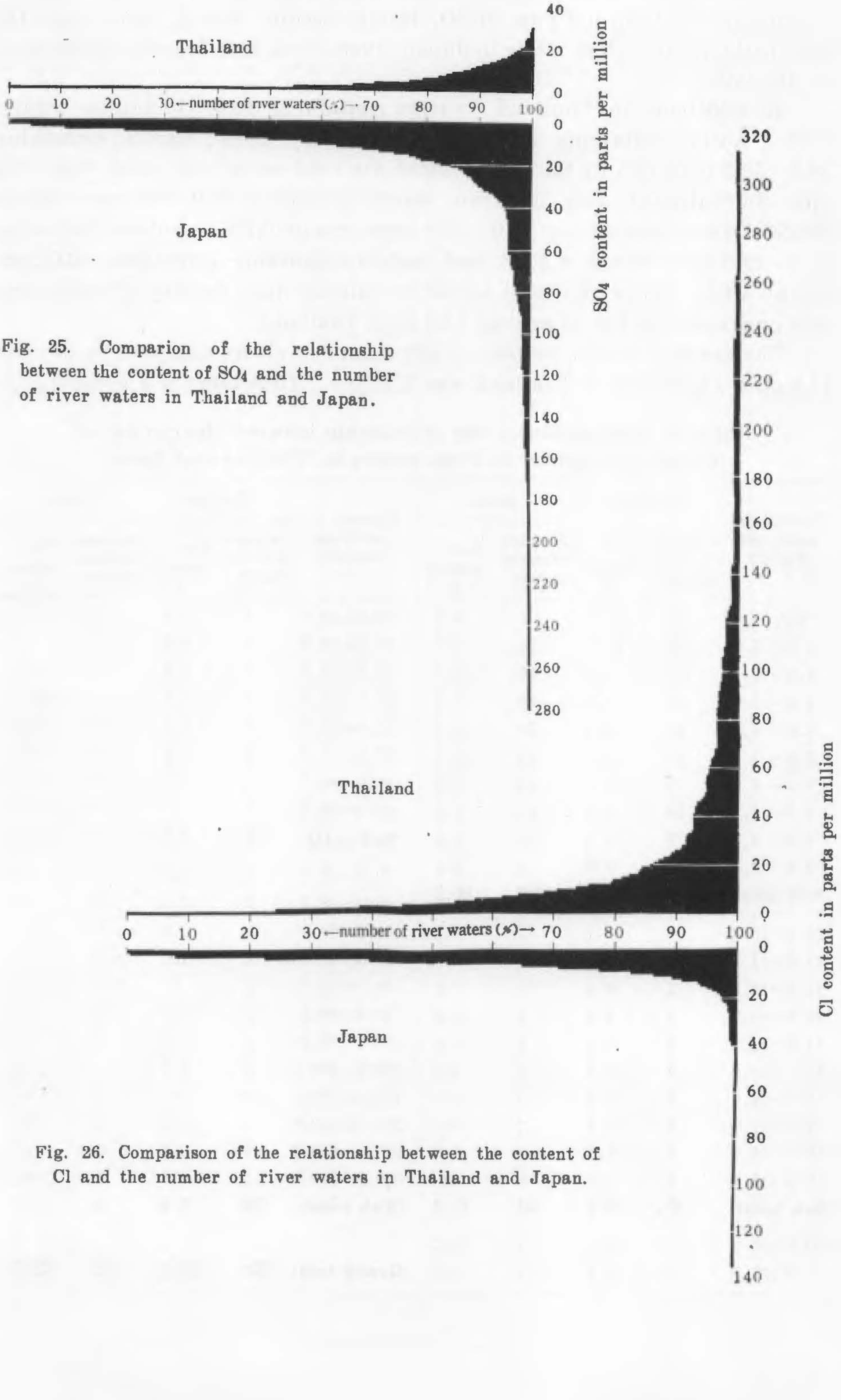


Fig. 25. Comparion of the relationship between the content of SO_4 and the number of river waters in Thailand and Japan.

Fig. 26. Comparison of the relationship between the content of Cl and the number of river waters in Thailand and Japan.

in volcanic Japan. As is shown in Table 7 and Fig. 25, waters of Thailand containing less than 0.9 ppm of SO_4 density occupy 54.4 %, more than the half of the river waters while in Japan rivers with such scarcity practically do not exist.

In addition, in Thailand, waters containing 10.0—19.9 ppm occupy 9.3% ; waters containing 20.0—29.9 ppm occupy 2.1% ; waters containing 30.0—39.9 ppm occupy 0.3% and there are none containing more than 40.0 ppm. In contrast to this, in Japan, waters containing 10.0—19.9 ppm occupy 25.4% ; waters containing 20.0—29.9 ppm occupy 6.1% ; waters containing 30.0—39.9 ppm occupy 4.4% ; and waters containing more than 40.0 ppm occupy 4.4%. All in all, total waters containing high density of more than 10.0 ppm reach 40.3% as against 11.7% in Thailand.

The average of SO_4 content in 382 Japanese rivers analysed by me was 14.0 ppm while that of Thailand was 3.3 ppm. Thus there is a great differ-

Table 8. Comparison of the relationship between the content of Cl and the number of river waters in Thailand and Japan.

Content in parts per million	Thailand		Japan		Content in parts per million	Thailand		Japan	
	Number of river waters	Frequency %	Number of river waters	Frequency %		Number of river waters	Frequency %	Number of river waters	Frequency %
0 ~ 0.9	81	24.2	2	0.5	22.0~22.9	3	0.9	1	0.3
1.0~ 1.9	46	13.7	28	7.3	23.0~23.9	1	0.3	0	0
2.0~ 2.9	24	7.2	56	14.7	24.0~24.9	2	0.6	0	0
3.0~ 3.9	30	9.0	65	17.0	25.0~25.9	3	0.9	1	0.3
4.0~ 4.9	11	3.3	50	13.1	26.0~26.9	1	0.3	0	0
5.0~ 5.9	14	4.2	47	12.3	27.0~27.9	2	0.6	0	0
6.0~ 6.9	9	2.7	23	6.0	28.0~28.9	0	0	0	0
7.0~ 7.9	14	4.2	25	6.5	29.0~29.9	0	0	0	0
8.0~ 8.9	7	2.1	20	5.2	**Sub total**	17	5.1	5	1.4
9.0~ 9.9	10	3.0	14	3.7	30.0~39.9	4	1.2	3	0.8
Sub total	246	73.6	330	86.3	40.0~49.9	7	2.1	0	0
10.0~10.9	7	2.1	12	3.1	50.0~59.9	1	0.3	0	0
11.0~11.9	12	3.6	6	1.6	60.0~69.9	4	1.2	0	0
12.0~12.9	1	0.3	10	2.6	70.0~79.9	0	0	0	0
13.0~13.9	5	1.5	2	0.5	80.0~89.9	1	0.3	0	0
14.0~14.9	4	1.2	4	1.0	90.0~99.9	2	0.6	0	0
15.0~15.9	5	1.5	3	0.8	100.0~149.9	6	1.8	1	0.3
16.0~16.9	1	0.3	3	0.8	150.0~199.9	0	0	0	0
17.0~17.9	1	0.3	2	0.5	200.0~249.9	1	0.3	0	0
18.0~18.9	5	1.5	1	0.3	250.0~299.9	1	0.3	0	0
19.0~19.9	2	0.6	0	0	300.0~349.9	1	0.3	0	0
Sub total	43	12.9	43	11.2	**Sub total**	28	8.4	4	1.1
20.0~20.9	2	0.6	1	0.3					
21.0~21.9	3	0.9	2	0.5	**Grand tolal**	334	100.0	382	100.0

ence in the amount of SO_4 content in the two countries showing that the amount in Japan is predominantly abundant.

Japan is a special example of volcanic countries where rivers with abundance of sulfate and showing strong acidity are distributed. These acid rivers inflict not only harmful effects on agriculture and fishery but also the distribution of these rivers has direct relationship with the cerebral hemorrhage death rate in Japan which is the highest in the world as I have already pointed out. (Kobayashi, 1957)

(f) *Chloride.*

The comparison between the two countries is shown in Table 8 and Fig. 26. If comparison in frequency is made limiting to waters containing extremely scarce amount of Cl content of less than 0.9 ppm, the percentage in Japan is 0.5% while it is 24.2% in Thailand showing far higher frequency in Thailand. On the other hand, waters containing high density of more than 30.0ppm occupy 1.1% in Japan while that of Thailand is 8.4%. The percentage of waters containing 20.0—29.9 ppm is 1.4% in Japan while that of Thailand is 5.1% showing greater numbers in Thailand. Thus waters containing extremely scarce amount as well as extremely abundant amount of Cl are more numerous in Thailand.

In contrast to the total average of Cl content in the Japanese rivers at 6.4 ppm, that of Thailand is 12.7 ppm amounting to 2 times of that of Japan.

However, rivers containing abundant amount of Cl content are limited to those in the Korat Plateau. If calculated omitting these rivers in view of the Korat Plateau being a peculiar area containing salt rock formations, the average in Thailand will be 4.7 ppm, and it can be seen that there is more

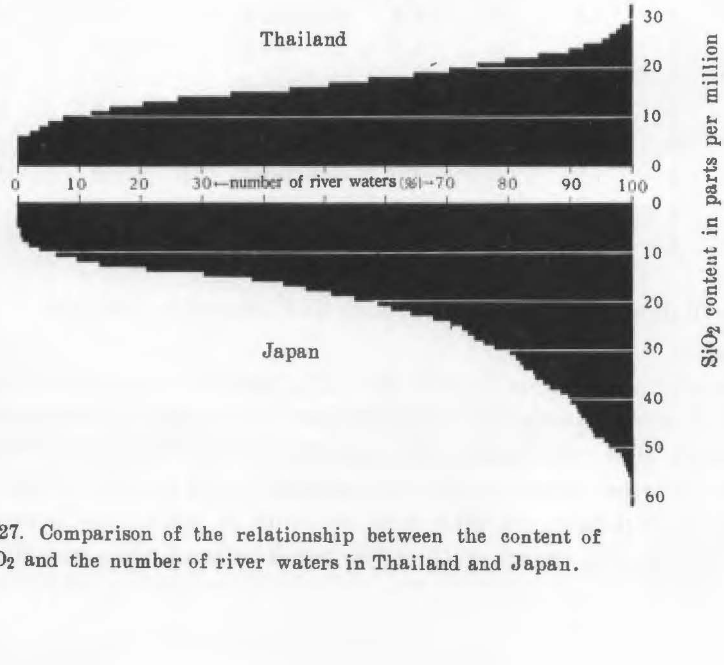


Fig. 27. Comparison of the relationship between the content of SiO_2 and the number of river waters in Thailand and Japan.

Table 9. Comparison of the relationship between the content of SiO_2 and the number of river waters in Thailand and Japan.

Content in parts per million	Thailand		Japan	
	Number of river waters	Frequency %	Number of river waters	Frequency %
0~ 0.9	0	0	0	0
1.0~ 1.9	0	0	0	0
2.0~ 2.9	0	0	0	0
3.0~ 3.9	0	0	0	0
4.0~ 4.9	0	0	2	0.5
5.0~ 5.9	7	2.1	0	0
6.0~ 6.9	5	1.5	1	0.3
7.0~ 7.9	5	1.5	4	1.0
8.0~ 8.9	8	2.4	7	1.8
9.0~ 9.9	15	4.5	10	2.6
Sub total	40	12.0	24	6.2
10.0~10.9	10	3.0	13	3.4
11.0~11.9	18	5.4	14	3.7
12.0~12.9	19	5.7	29	7.6
13.0~13.9	28	8.3	36	9.4
14.0~14.9	32	9.5	29	7.6
15.0~15.9	22	6.6	20	5.2
16.0~16.9	22	6.6	14	3.7
17.0~17.9	25	7.5	16	4.2
18.0~18.9	19	5.7	15	3.9
19.0~19.9	16	4.8	14	3.7
Sub total	211	63.1	200	52.4
20.0~20.9	15	4.5	9	2.4
21.0~21.9	18	5.4	12	3.1
22.0~22.9	16	4.8	14	3.7
23.0~23.9	8	2.4	11	2.9
24.0~24.9	10	3.0	7	1.8
25.0~25.9	4	1.2	4	1.0
26.0~26.9	4	1.2	4	1.0
27.0~27.9	2	0.6	6	1.6
28.0~28.9	5	1.5	6	1.6
29.0~29.9	0	0	10	2.6
Sub total	82	24.6	83	21.7
30.0~30.9	0	0	4	1.0
31.0~31.9	0	0	3	0.8
32.0~32.9	1	0.3	2	0.5
33.0~33.9	0	0	6	1.6
34.0~34.9	0	0	1	0.3
35.0~35.9	0	0	5	1.3
36.0~36.9	0	0	4	1.0
37.0~37.9	0	0	6	1.6
38.0~38.9	0	0	5	1.3
39.0~39.9	0	0	2	0.5
Sub total	1	0.3	38	9.9
40.0~40.9	0	0	3	0.8
41.0~41.9	0	0	1	0.3
42.0~42.9	0	0	2	0.5
43.0~43.9	0	0	3	0.8
44.0~44.9	0	0	2	0.5
45.0~45.9	0	0	2	0.5
46.0~46.9	0	0	1	0.3
47.0~47.9	0	0	6	1.6
48.0~48.9	0	0	3	0.8
49.0~49.9	0	0	4	1.0
50.0~54.9	0	0	8	2.1
55.0~59.9	0	0	1	0.3
60.0~64.9	0	0	1	0.3
Sub total	0	0	37	9.8
Grand total	334	100.0	382	100.0

abundance in Japan which is surrounded and afected by the sea.

(g) *Silica.*

As is shown in Table 9 and Fig. 27, there is not much difference in frequency of river waters between the two countries, if the calculation is limited within 10.0—29.9 ppm, showing 87.7% for Thailand and 74.1% for Japan. On the other hand, if the comparison in the number of river waters containing high density of 30.0 ppm or more is made, the percentage for Japan is 19.7% compared with 0.3% for Thailand thus showing higher frequency in Japan.

The percentage of the number of rivers containing scarce amount of less than 9.9 ppm is 6.2% for Japan as against 12.0% for Thailand.

In contrast to the total average of the amount of SiO_2 content in Japan at 21.6 ppm, that of Thailand is 16.0 ppm and the tendency is noticed that the content is higher in Japan where there is the influence of weathering of volcanic rocks.

However, the distribution of rivers containing high density of 30.0 ppm or more in Japan is concentrated in the volcanic areas in Kyushu Island,

Table 10. Comparison of the relationship between the content of dissolved solids and the number of river waters in Thailand and Japan.

Content in parts per million	Thailand		Japan		Content in parts per million	Thailand		Japan	
	Number of river waters	Frequency %	Number of river waters	Frequency %		Number of river waters	Frequency %	Number of river waters	Frequency %
0 ~ 4.9	0	0	0	0	130.0~134.9	7	2.1	3	0.8
5.0~ 9.9	0	0	0	0	135.0~139.9	8	2.4	6	1.6
10.0~14.9	0	0	0	0	140.0~144.9	12	3.6	3	0.8
15.0~19.9	0	0	0	0	145.0~149.9	8	2.4	3	0.8
20.0~24.9	0	0	0	0	**Sub total**	111	33.1	61	15.9
25.0~29.9	2	0.6	0	0	150.0~154.9	10	3.0	1	0.3
30.0~34.9	8	2.4	1	0.3	155.0~159.9	7	2.1	1	0.3
35.0~39.9	10	3.0	6	1.6	160.0~164.9	8	2.4	1	0.3
40.0~44.9	10	3.0	9	2.3	165.0~169.9	10	3.0	3	0.8
45.0~49.9	5	1.5	23	6.0	170.0~174.9	4	1.2	1	0.3
Sub total	35	10.5	39	10.2	175.0~179.9	9	2.7	1	0.3
50.0~54.9	9	2.7	31	8.1	180.0~184.9	6	1.8	2	0.5
55.0~59.9	9	2.7	32	8.4	185.0~189.9	2	0.6	0	0
60.0~64.9	7	2.1	36	9.4	190.0~194.9	1	0.3	1	0.3
65.0~69.9	9	2.7	36	9.4	195.0~199.9	1	0.3	3	0.8
70.0~74.9	10	3.0	27	7.0	**Sub total**	58	17.4	14	3.9
75.0~79.9	14	4.2	23	6.0	200.0~249.9	11	3.3	4	1.0
80.0~84.9	14	4.2	18	4.7	250.0~299.9	8	2.4	3	0.8
85.0~89.9	11	3.3	17	4.4	300.0~349.9	1	0.3	0	0
90.0~94.9	12	3.6	21	5.5	350.0~399.9	0	0	1	0.3
95.0~99.9	12	3.6	18	4.7	400.0~449.9	0	0	0	0
Sub total	107	32.1	259	67.6	450.0~499.9	0	0	0	0
100.0~104.9	12	3.6	12	3.1	500.0~549.9	2	0.6	0	0
105.0~109.9	13	3.8	13	3.4	550.0~599.9	0	0	1	0.3
110.0~114.9	10	3.0	4	1.0	600.0~649.9	0	0	0	0
115.0~119.9	15	4.4	9	2.3	650.0~699.9	1	0.3	0	0
120.0~124.9	14	4.2	3	0.8	**Sub total**	23	6.9	9	2.4
125.0~129.9	12	3.6	5	1.3	**Grand total**	334	100.0	332	100.0

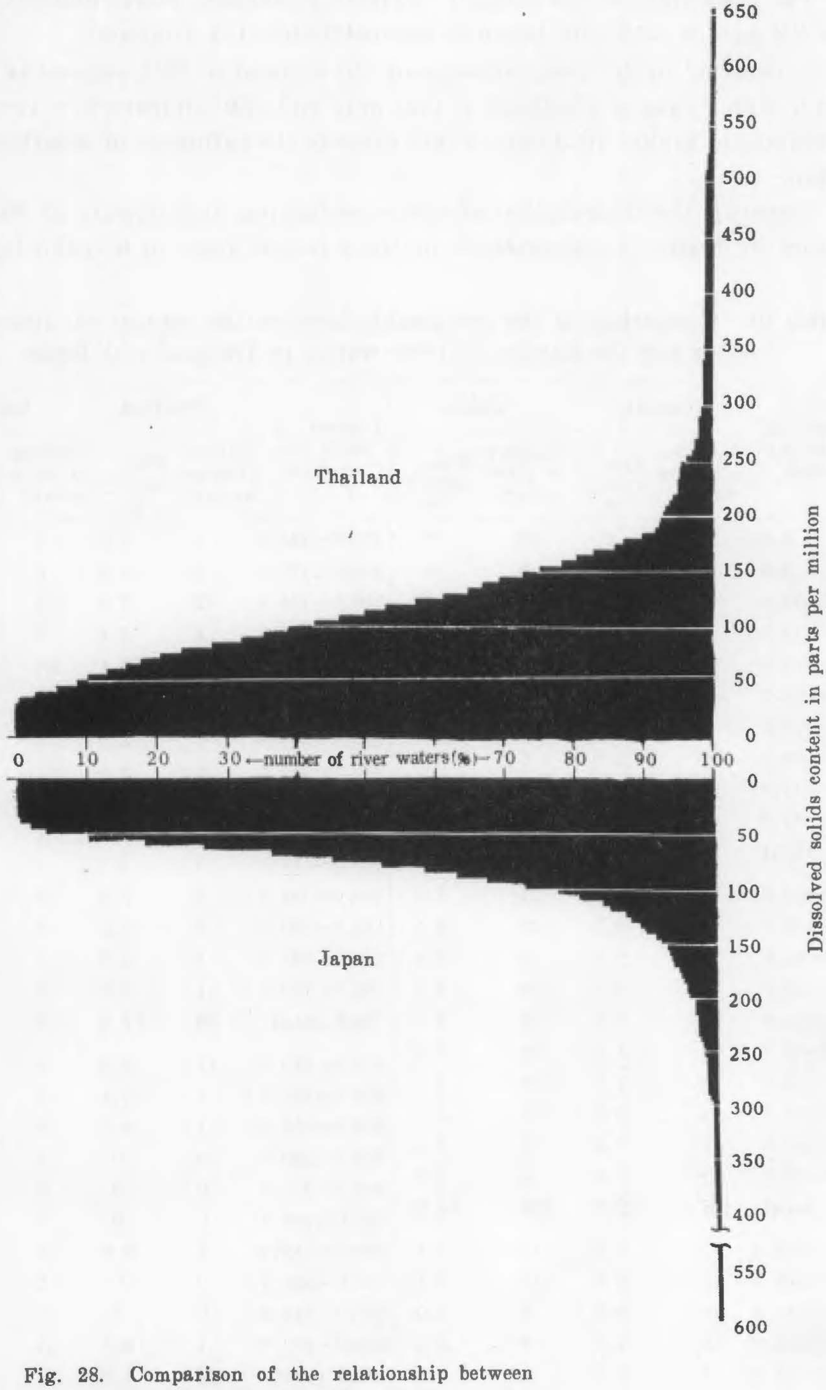


Fig. 28. Comparison of the relationship between the content of dissolved solids and the number of river waters in Thailand and Japan.

Kanto Districts and Hokkaido Island. If calculation is made omitting these areas, the difference in the amount of SiO_2 content between the two countries will be very much narrowed.

(h) *Dissolved solids.*

The comparison of dissolved solids in both countries is shown in Table 10 and Fig. 28. The percentage of waters containing scarce dissolved solids such as 50.0—99.9 ppm is 67.6% or more than half of all rivers in Japan while it is 32.1 %in Thailand.

33.1% of rivers in Thailand contain 100.0—149.9 ppm and 17.4% contain 150.0—199.9 ppm while 6.9% contain more than 200.0 ppm. Thus the total of rivers containing more than 100.0 ppm reaches 57.4%. But in Japan such rivers only occupy 22.2%.

On the other hand, the average amount of dissolved solids contained in Japan is 85.3 ppm while that of Thailand is 115.2 ppm. showing that the

Table 11. Comparison of the relationship between the content of suspended solids and the number of river waters in Thailand and Japan.

Content in parts per million	Thailand		Japan		Content in parts per million	Thailand		Japan	
	Number of river waters	Fre-queney %	Number of river waters	Fre-quency %		Number of river waters	Fre-quency %	Number of river waters	Fre-quency %
0~4.9	5	1.7	1535	47.4	110.0~114.9	3	1.0	5	0.2
5.0~9.9	14	4.6	679	21.0	115.0~119.9	4	1.3	8	0.2
10.0~14.9	22	7.3	286	8.8	120.0~124.9	1	0.3	2	0.1
15.0~19.9	19	6.3	159	4.9	125.0~129.9	0	0	4	0.1
20.0~24.9	19	6.3	114	3.5	130.0~134.9	4	1.3	2	0.1
25.0~29.9	18	5.9	67	2.1	135.0~139.9	1	0.3	5	0.2
30.0~34.9	15	4.9	46	1.4	140.0~144.9	3	1.0	4	0.1
35.0~39.9	14	4.6	43	1.3	145.0~149.9	1	0.3	1	0
40.0~44.9	13	4.3	30	0.9	150.0~199.9	17	5.6	23	0.7
45.0~49.9	9	3.0	30	0.9	**Sub total**	41	13.4	65	2.1
Sub total	148	48.9	2989	92.2	200.0~249.9	11	3.6	12	0.4
50.0~54.9	9	3.0	19	0.6	250.0~299.9	7	2.3	7	0.2
55.0~59.9	6	2.0	24	0.6	300.0~349.9	4	1.3	5	0.2
60.0~64.9	9	3.0	17	0.5	350.0~399.9	2	0.7	5	0.2
65.0~69.9	10	3.3	11	0.3	400.0~449.9	3	1.0	2	0.1
70.0~74.9	7	2.3	12	0.4	450.0~499.9	3	1.0	6	0.2
75.0~79.9	8	2.6	10	0.3	500.0~999.9	10	3.3	9	0.3
80.0~84.9	9	3.0	18	0.6	1000.0~1499.9	2	0.7	1	0
85.0~89.9	9	3.0	9	0.3	1500.0~1999.9	1	0.3	2	0.1
90.0~94.9	3	1.0	8	0.2	2000.0~2499.9	0	0	0	0
95.0~99.9	1	0.3	7	0.2	2500.0~2000.0	0	0	1	0
Sub total	71	23.5	135	4.0	**Sub total**	43	14.2	50	1.7
100.0~104.9	6	2.0	6	0.2	**Grand total**	303	100.0	3239	100.0
105.0~109.9	1	0.3	5	0.2					

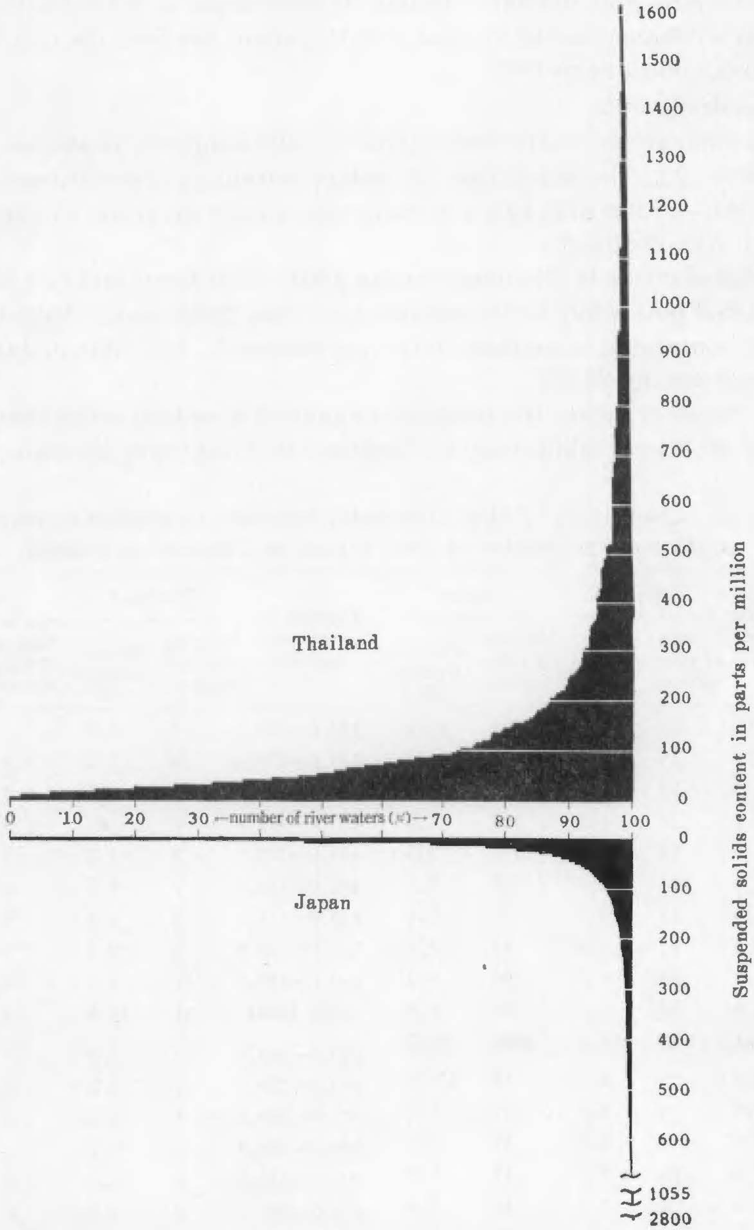


Fig. 29. Comparison of the relationship between the content of suspended solids and the number of river waters in Thailand and Japan.

density of dissolved salts is abundant in Thai rivers while it is scarce in Japanese rivers.

(i) *Suspended solids.*

As is shown in Table 11 and Fig. 29, suspended solids are remarkably abundant in Thailand. In Japan, the percentage of river waters containing 0.0—4.9 ppm of suspended solids is 47.4% and that of river waters containing 5.0—9.9 ppm is 21.0%. Thus, the total number of clear and transparent river waters containing less than 9.9 ppm occupies 68.4% which is more than the half. But the percentage of Thai river waters containing such a scarce amount of suspended solids is only 6.3%. In Thailand, 23.5% of river waters contain 50.0—99.9 ppm ; 13.4% of river waters contain 100.0—199.9 ppm ; and 14.2% of river waters contain more than 200.0 ppm. All in all, the percentage of river waters containing more than 50.0 ppm reaches 51.1% which is about the half of all river waters. However, in Japan the percentage of river waters containing such abundance is only 7.8% in all.

Thus it can be concluded that compared with the river waters in Japan, those of Thailand contain not only abundance of dissolved solids but also abundance of turbid materials, having the effect of supplying additioned productive soil to paddy fields from the agricultural point of view.

XI. QUANTITY OF FERTILIZING SUBSTANCES SUPPLIED BY RIVERS

In this last chapter, I will calculate the quantity of fertilizing substances in the rice-fields supplied naturally by rivers in solution.

In order to do this, the volume of water which is necessary for the growth of rice—in other words, total amount of the 3 volumes of waters i. e. the volume of water lost by the permeation through the soil of rice fields, the volume of water lost by transpiration from the leaves of the rice and the volume of water evaporated from the surface of the rice fields—must be ascertained as the prerequisite.

However, the volume of water permeated through the soil varies greatly depending on the nature of soil and the location while the volume of water evaporated from the leaves of the rice and the surface of the rice fields shows great difference depending on the climate, kind of rice and other conditions of cultivation.

Because of these reasons, experimental results vary (5,500 to 22,000 cubic meters per one hectare) in spite of the fact that many investigations and experiments have been made concerning this problem for many years.

Thus, the fundamental standard of the necessary volume of water has not yet been ascertained.

However, S. Mizutani (19—), a former engineer of the Home Ministry, states that the volume of water which is necessary for the growth of rice in the normal rice fields in Japan is 0.0014—0.002 cubic meters per second for one hectare. If the rice fields are irrigated for 100 days by this volume of water, it is calculated that about 15,000 cubic meters are necessary for one hectare of rice field. (When the volume of water in the rice field, about 1.5

cm. in depth for a day, is irrigated for 100 days, it comes to 15,000 cubic meters.) Therefore, in case the amount of fertilizing substances contained in the irrigation water is 1 part per million, the amount of fertilizing substances supplied for one hectare of rice field corresponds to 15kg. However, this is a material in Japan and it will be unreasonable to apply this material as it is to Thailand. In view of non-existence of better materials, the amount of fertilizing substances naturally supplied by waters in Thailand is calculated as follows based on this material.

First, the maximum content of potassium is 4.4 ppm in the water of the middle stream (at Uthai Thani) of the Mae Nam Chao Phraya followed by 4.3 ppm of the Supan River and 4.2 ppm of the Phao River. So, the quantity of fertilizing substance as potash (K_2O) amounts to 76—80 kg. for one hectare during the rice cultivating season. On the other hand, the minimum quantities of potassium contained are 1.1 ppm of the Nan River (at Nan) and 1.3 ppm of the Sai Buri River meaning respectively 20 kg. and 23 kg. of fertilizing substance as potash for one hectare. Thus, there are substantial differences in the quantity supplied between rivers. However, the average content of potassium during one year of 30 places scattered throughout Thailand being 2.5 ppm, the average quantity of potash supplied for each one hectare is 45 kg.

This figure multiplied by 5,500,000 hectares, which are the whole area of rice-fields in Thailand makes 248,000,000 kg., which correspond to around 500,000 tons of potassium sulfate. This is the quantity of potash which the rivers supply naturally in solution during one rice-growing season to the whole rice-fields in Thailand.

As has been stated before, the average quantity of potassium contained in the Thai rivers being 2 times that of Japan, Thailand is in an advantageous position insofar as the rice-growing is concerned.

By means of the same calculation concerning 3 kinds of nitrogen contained as nitrate, ammonia and albuminoid and converted into ammonium sulfate, it corresponds to 18 kg. per one hectare in the average and amounts to 100,000 tons for the whole rice-fields in Thailand.

As to the quantity of silica supplied by river-water, which is an important fertilizing substance for strengthening the resisting power of rice against rice-blast, the maximum is 350 kg. of the Pa Sak River (at Petchabun) and the Ping River (at Chiengmai) while the minimums are 95 kg. of Lake Nong Han and 152 kg. of the Chi River (at Kon Khen) and the average quantity of supply, calculated by the simple average of 30 places, is 240 kg. Accordingly, silica such as 1,300,000 tons is supplied in solution during one rice-growing season to the whole rice-fields in Thailand.

In addition, if the quantity of calcium carbonate which serves to neutralize acid soil (it is said that acid soil is abundant in the rice-fields in Thailand) is calculated from alkalinity, it is from 190 to 2,000 kg. per one hectare of fields and the average is 1,000 kg.; so it becomes 5,500,000 tons for all the rice-fields.

Though the above is the result of calculation based on the assumption that the quantity of water nccessary for growing rice is 15,000 cubic meters per one hectare of the rice-field, it shows that the rivers in Thailand give unexpectedly large fertilizing effect on rice-growing.

XII. CONCLUSIONS

1) In order to ascertain the general tendency of the nature of water in Thailand, I have chosen 28 rivers, 2 lakes and 1 city water. Sample waters were collected 12 times during one year from July 15, 1956 to June 15, 1957 and I repeated the chemical analysis regarding these waters. The sesult is shown in Table 2 and Fig. 30—32.

2) The amount of Ca content differs greatly from river to river. The average content during the year in the Pa Sak River flowing in the eastern part of the central great plain contains 46.8 ppm while the Sai Buri River in the Malay peninsula contains only 1.9 ppm. The amount of Ca content in the Pa Sak River changes with a wide range depending on the season such as 73.8 ppm in the dry season and 12.1 ppm in the rainy season. In addition to that, the sample waters taken in the dry season showed the decreases of Ca and alkalinity by half leaving precipitate of $CaCO_3$ while it was being stored in the laboratory. On the other hand, the amount of Ca content in the Sai Buri River showed only a change ranging from 1.1 to 2.4 ppm.

3) The distribution of Ca in the country is shown in Fig. 2. According to that Figure, Ca is abundant in the central great plain (the two basins of the Mae Nam Chao Phraya and the Mae Klong River) and in the main stream of the Mae Khong River while it is scarce in the east coast, the Malay peninsula and the Korat Plateau.

4) The content of Mg ranges within 0.7—8.6 ppm. The Mae Klong River is most abundant while Lake Non Han, the Chantaburi River and the Sai Buri River are most scarce.

The distribution of Mg in Thailand is shown in Fig. 4 showing not much difference compared with that of Ca.

5) Rivers in the Korat Plateau contain abundance of Na due to the influence of salt oozing out from the sand stone formations in the same Plateau. The Chi River flowing eastward in the center of the Korat Plateau contains 192.9 ppm at the peak in the dry season and 3.9 ppm at the lowest in the rainy season as is shown in Fig. 5 indicating extremely great seasonal change.

However, the content of Na is scarce in the northern and western part of Thailand and the Malay peninsula as is shown in the distribution chart Fig. 6.

6) Among the average content of K during one year, 4.4 ppm is the

highest value, and 1.1 ppm is the lowest. Its distribution is shown in Fig. 7 which shows that potassium is abundant in the basin of the Mae Nam Chao Phraya, the principal rice producing area in Thailand and the Korat Plateau while it is scarce in other areas.

7) Alkalinity (HCO_3) is highest in the Pa Sak River as in the case of Ca content. Its seasonal change is shown in Fig. 3 indicating 256.8 ppm at the peak and 50.7 ppm at the lowest. The distribution of alkalinity in Thailand is shown in Fig. 8 indicating that the amount is abundant in the central great plain and is scarce in the Korat Plateau, the east coast and the Malay peninsula. The distribution of alkalinity is about the same as in the case of Ca.

8) 17.1 ppm which is the quantity of SO_4 contained in the Mae Khong River at Chiengsan, the northern most part in Thailand is most abundant except the city water of Bangkok. The distribution of SO_4 in Thailand is shown in Fig. 9 indicating that 18 out of 31 places investigated have dilute waters containing less than 1.9 ppm.

9) The rivers in the Korat Plateau contain abundance of Cl as in the case of Na. Among these, values in the dry season of the Chi River (at Kon Khen) and the Mun River (at Surin) are extremely abundant. Therefore, it is concluded that the place where the rivers in the Korat Plateau are most influenced by rock salt is located near Kon Khen and Surin.

The seasonal change of the amount of Cl content of the Chi River is shown in Fig. 5 showing wide range of change such as 312.5 ppm at the peak in the dry season and 4.7 ppm at the lowest in the rainy season.

On the other hand, Cl content in the northern and western part of the central great plain and the Malay peninsula is scarce as is shown in the distribution of Cl in Thailand in Fig. 10. This is especially so in the case of the rivers Ping, Yom and Wang indicating that the average content during the year is only 0.5—0.8 ppm.

10) The average content of SiO_2 during the year is within the range of 6.3—23.7 ppm. As is shown in Fig. 11 it is abundant in the basin of the Mae Nam Chao Phraya, the principal rice producing area in Thailand and is scarce in the Korat Plateau, the east coast and the Malay peninsula.

11) The quantity of dissolved solids is most abundant in the Chi River which contains abundance of salt content showing the figure of 244.7 ppm and in the Pa Sak River which contains abundance of Ca and alkalinity showing the figure of 182.3 ppm, while 35.3 ppm in the Sai Buri River in the Malay peninsula and 36.5 ppm in the Chantaburi River in the east coast are most scarce. The distribution of dissolved solids in Thailand is shown in Fig. 12 which indicates the tendency of the east coast and the Malay peninsula being scarce and other areas being abundant.

12) The distribution of suspended solids is shown in Fig. 13 which indicates that the amount in the basin of the Mae Nam Chao Phraya and the

main stream of the Mae Khong River is abundant and that of the Malay peninsula is scarce.

The changes during the year of the Nan River which has the highest are shown in Fig. 14 indicating remarkable changes of 1,436.4 ppm at the peak in the rainy season and 28.8 ppm at the lowest in the dry season. On the other hand, the Sai Buri River which contains scarce amount of suspended solids shows 82.6 ppm at the peak and 8.9 ppm at the lowest.

13) In order to ascertain the difference of metals contained in the suspended solids, spectrophotogram is shown in Fig. 20 which indicates that in the three rivers, Pa Sak, Kwae Noi and Mae Klong, calcium carbonate is flowing in the form of solid objects not entirely dissolved and also there is tin in the Kwae Noi River, silver in the Tapi River in abundance.

14) The tendency of turbidity corresponds roughly to that of the suspended solids. The turbidity in the Nan River is most abundant and the waters in the rivers and lakes in the peninsula are clear and transparent.

15) pH ranges between 5.9 as the lowest and 7.1 as the highest. Inspite of the big influence of lime rock, the rivers showing weak acid reaction are predominantly numerous due to the influence of organic matters. Among 31 places investigated, those showing less than pH 6.8 numbers 23.

16) The characteristics of the two basins of the Mae Nam Chao Phraya and the Mae Klong River both flowing in the central great plain are the abundance of Ca and alkalinity and the remarkable influence of lime rock extending over wide areas. In addition, K and SiO_2 which are important components for agriculture are abundant in the basin of the Mae Nam Chao Phraya and also Mg is abundant in the Mae Klong River.

On the other hand, scarcity of Cl and SO_4 is another characteristic of these two basins.

17) Compared with the average waters in Thailand, the Mae Khong River contains not only remarkably abundant amount of SO_4 but also abounds in Ca, Mg, alkalinity, suspended solids etc. and contains scarce amount of Na, K, and Cl.

While the Mae Khong River flows along the frontier of Thailand, Ca decreases from 32.1 to 26.8 ppm; HCO_3 decreases from 116.9 to 100.3 ppm; SO_4 decreases from 17.1 to 12.2 ppm; and dissolved solids decreases from 145.3 to 124.3 ppm. Thus there is the tendency of salts becoming gradually scarcer, and it is my opinion that this tendency is due to the confluence with branch rivers with scarce content. In addition, while it flows downstream the tendency is noticed that suspended solids and turbidity decrease making the water clearer and more transparent.

18) The amount of mineral matters carried in solution in the Mae Khong River at Nongkai (near the opposite side of Vientiane, the capital of Laos) located 1,500 km. up stream from its river mouth is 0.65 ton per second amounting to 20,500,000 tons if accumulated on a yearly basis.

This amount corresponds to more than 16 times of 1,250,000 tons of mineral matters carried in solution during one year in the Tone River, the largest river in Japan. However, if this amount is divided by 287,000 km^2. which is the size of the basin at Nongkai, the amount of mineral matters, flowing out during one year per 1 km^2. of land is 71 tons. Comparing this figure with 80 tons of the Tone River and 220 tons of the Oyodo River in the Miyazaki Prefecture located in the south-western part of Japan, it can be known that the dissolution of land in the Mae Khong River is progressing rather slowly.

19) Due to the effect of monsoon, the year is distinctly divided into the rainy season and the dry season in Thailand. Dissolved salts become remarkably concentrated in the dry season while they become dilute in the rainy season. The seasonal changes in the Mae Khong River are shown in Fig. 15; the seasonal changes in the Mun River in the Korat Plateau are shown in Fig. 16; and the changes of the nature of water in the Mae Nam Chao Phraya and the Ping River are shown respectively in Fig. 17 and Fig. 18.

20) Among dissolved constituents in the Mun River which is affected by rock salt, those showing the sharpest increase or decrease depending on the season are Na and Cl with a density at the peak 20 times higher than that at the lowest. Ca, HCO_3 show 6—7 times in difference and SiO_2 shows only about 2 times. Thus the seasonal changes are not uniform depending on the constituents. The order is Na, Cl $>$ Ca, $HCO_3 > SiO_2$.

The order in the Mae Khong River which abounds in the sulfate content is SO_4, Cl, Na $>$ Mg, Ca, $HCO_3 > SiO_2$. Thus the seasonal changes of SiO_2 are the smallest.

21) The seasonal changes in the Sai Buri River in the southern most part of the Malay peninsula are shown in Fig. 19.

Due to the effect of the ocean weather accompanying large amount of rain, various dissolved constituents are dilute throughout the year, and there are no regular changes depending on the dry or rainy season as seen in other areas.

The average content of Cl during one year in the Sai Buri River is only 1.1 ppm showing slight effect of salts carried by the monsoon from the ocean.

22) In order to ascertain the difference of the nature of water in Thailand and Japan, the comparison of the relationship between the density of respective constituents and the frequency of river waters is shown in Table 3—11 and Fig. 21—29.

23) Fig. 21 and Fig. 24 show the comparison of calcium content and alkalinity between the two countries.

The average amount of Ca content in 382 rivers in Japan is 9.5 ppm as against 19.8 ppm of the average in Thailand which is the double of that in Japan. The amount of HCO_3 in Japan is 32.3 ppm as against 82.6 ppm which is 2.5 times of Japan.

Thus the influence of lime rock on river waters is far greater in Thailand than in Japan and the waters in Thailand have strong power to neutralize acidity.

Contrary to calcium and alkalinity, sulfate is remarkably abundant in Japan, as is shown in Fig. 25. The average amount of SO_4 content in Japan is 14.0 ppm which is more than 4 times of the Thai average of 3.3 ppm. Japan is a special volcanic country, where rivers with abundance of sulfate and showing strong acidity are distributed.

24) Fig. 23 shows the comparison of potassium content between the two countries. The total average content of K in rivers in Japan is 1.3 ppm as against the Thai average of 2.5 ppm which is the double of that in Japan. This means that it is very advantageous for growing rice in Thailand. In addition, the comparative rate of K/Na is higher in Thailand than in Japan.

25) The average content of Cl in Japanese rivers is 6.4 ppm as against the Thai average of 12.7 ppm. However, rivers containing abundance of Cl in Thailand are limited to those in the Korat Plateau. If calculation is made omitting the Korat Plateau which is a peculiar area containing rock salt formations, the average figure for Thailand will be 4.7 ppm showing the amount is abundant in Japan which is surrounded by the sea and is affected by salt carried by the wind.

26) The content of PO_4 at 30 places from among 31 places investigated in Thailand is 0.00—0.01 ppm. It is my opinion that the amount of phosphate content is scarcer in Thailand than in Japan due to the circumstances that rivers flow through tropical red soil containing abundance of iron.

27) The average amount of SiO_2 content in Japan is 21.6 ppm while that in Thailand is 16.0 ppm showing that the amount is abundant in volcanic Japan.

28) The amount of $KMnO_4$ consumed and albuminoid nitrogen are more abundant in Thailand than in Japan with the tendency of containing abundance of organic matters.

29) The average content of dissolved solids in Japan is 85.3 ppm as against Thailand's 115.2 ppm. Thus Japanese waters are dilute and those of Thailand are concentrated.

30) The content of suspended solids is far more abundant in Thai waters as is shown in Fig. 29, and also turbidity is higher in Thailand. I am of the opinion that from the agricultural point of view Thai waters have great effect of supplying additioned productive soil to paddy fields compared with clear and transparent waters in Japan.

31) When the volume of necessary water for one hectare of rice-fields during one rice-growing season is assumed as 15,000 cubic meters, the quantity of fertilizing substances supplied in solution by rivers is as follows though there are differences between rivers.

Potash (K_2O) is from 20 to 80 kg. per one hectare of fields and its average of 30 places is 45kg.; silica from 95 to 350 kg., its average 240 kg.; calcium carbonate from 190 to 2,000 kg. and its average is 1,000 kg. If estimated on the whole rice-field area of 5,500,000 hectares in Thailand, potash is 500,000 tons calculated as potassium sulfate; nitrogen is 100,000 tons calculated as ammonium sulfate; silica is 1,300,000 tons; and calcium carbonate is as much as 5,500,000 tons.

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