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THE RELATION BETWEEN CHLORINITY AND SILICATE
CONCENTRATION OF WATER OBSERVED
IN SOME ESTUARIES

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With 5 Text-figures and 1 Table

The most important problem near the estuaries may be the investigation of the influence of the sea water upon the river water and *vice versa*. By stochastic analysis of previous data, I found that the concentration of chlorine (dominant in sea water) and that of silicate (dominant in river water) alter near the estuary in a correlated manner which may be represented by a nearly exact linear formula. In this report I want to propose an actual relation formula deduced from the calculated data of 9 observations in two inlet bays, Yosa-naikai and Kojima Bay.

I wish to express my sincere thanks to Prof. Dr. D. MIYADI (Biologist) and Prof. Dr. M. ISHIBASHI (Chemist) of Kyôto University and their co-workers for their kind assistance, valuable advices and criticisms given to me.

Method, Descriptions on Stations and Results Obtained

Method: Water samples were taken from various depths at each station shown in Figs. 1 and 2 and treated immediately after the field work or in the next day. The chlorinity (%) is determined by MOHR's silver titration method, and the silicate concentration (γ/L) by DIENERT-WANDENBLUCK's colorimetric method.

At the stochastic analysis of the obtained data, the sample correlation coefficient between silicate concentration and chlorinity was calculated respectively on each group of water samples which are regarded as being affected by the same river. To examine its significance, F_0 was computed setting the null hypothesis that the universe correlation coefficient (ρ) might be 0, and compared with the values in F table to find the level of significance. The

result was that the silicate concentration and chlorinity is negatively correlated to a great extent at each station. Then, for the universe regression equation, $[\text{SiO}_2] = \beta_0 + \beta_1 [\text{Cl}]$, β_0 and β_1 were estimated.

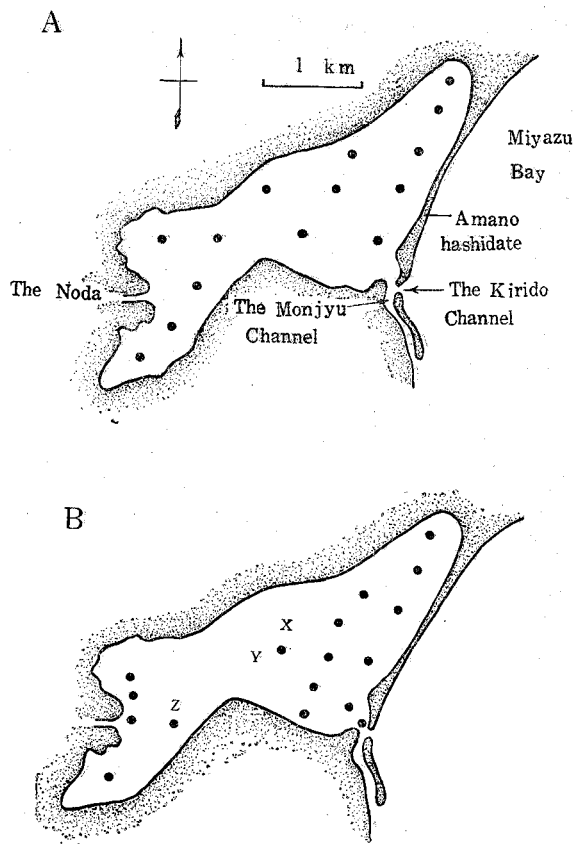


Fig. 1. Map of Yosa-naikai, showing the location of station. (A: 1950, III, 19 and V, 10-12. B: 1950, IX, 30-X, 1.) X-Y-Z indicates the location of slick observed. Water samples were taken from each side of this line.

Yosa-naikai: Yosa-naikai is a lagoon faced to Wakasa Bay of Japan Sea, just northwest of Kyôto, and is separated from the open sea by a narrow sand barrier known as "Amano-hashidate", one of the three famous sights in Japan, leaving at the south eastern corner two small canals through which the sea water flows in. The river Noda pours into the lagoon near its south western corner. My first observation was made on March 19, 1950 in the eastern part of the lagoon. The second one was performed on the whole

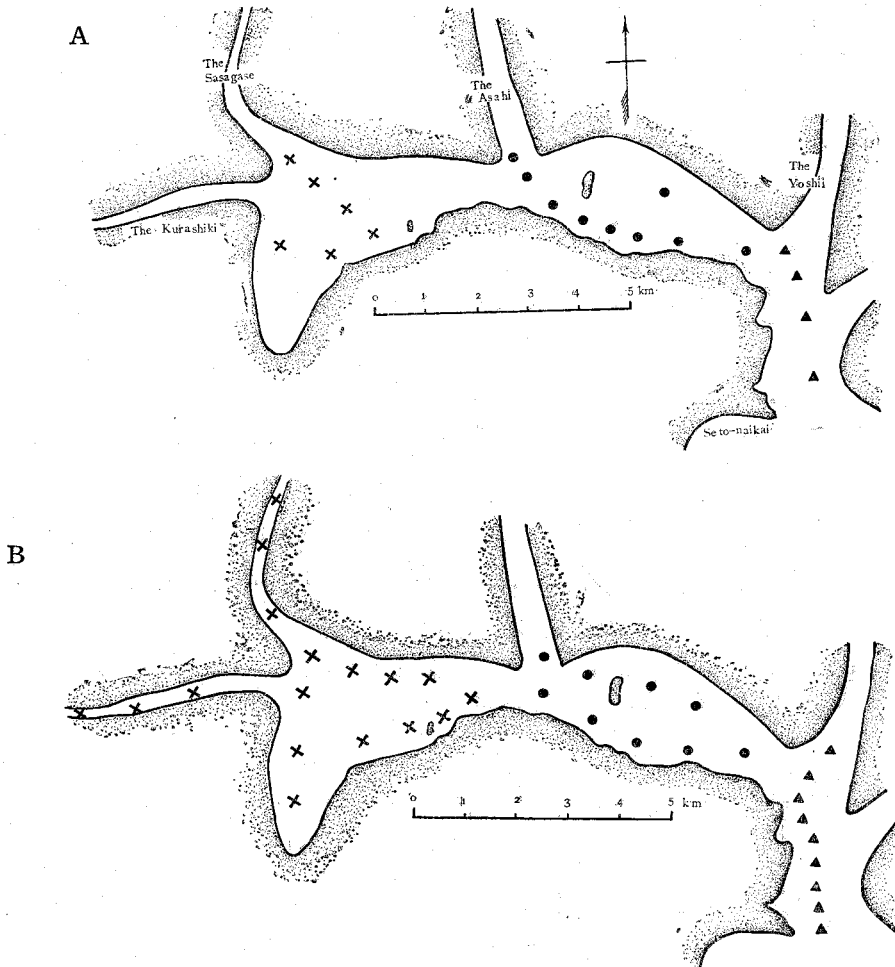


Fig. 2. Map of Kojima Bay, showing the location of stations. (A: 1951, V, 26-31. B: 1952, II, 26-27.)

- × — indicates the stations retaining the water derived from the river Sasagase.
- — indicates the stations retaining the water derived from the river Asahi.
- ▲ — indicates the stations retaining the water derived from the river Yoshii.

lagoon during the period from 10th to 12th of May, 1950. In this observation, the silicate concentration increased near the surface influenced by the river water and also near the bottom affected by the substratum. The silicate minimum layer was found at a little upper layer than the middle. Thus it may be considered very reasonable to treat the data in two groups, the shallower ones than the silicate minimum layer and the deeper ones. The non-participation ratio of the latter is larger than 0.75, and the variation of silicate concentration is relatively larger than that of chlorinity which may be able to

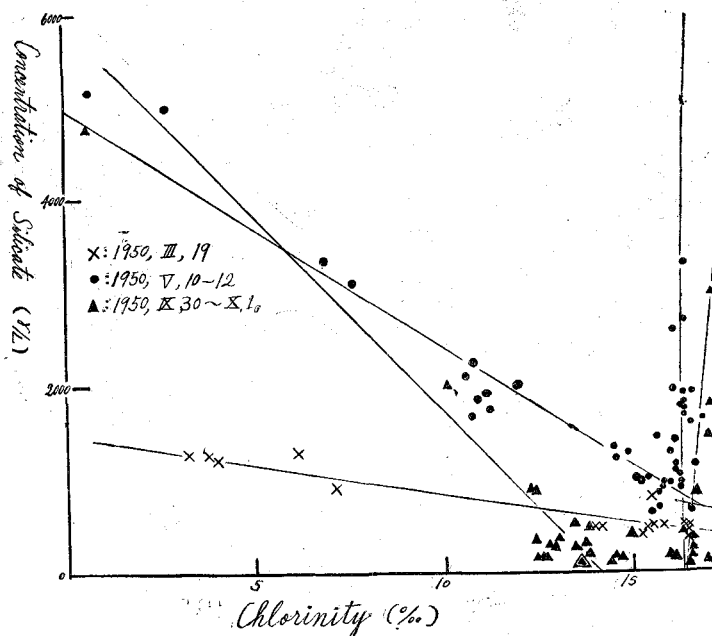


Fig. 3. Silicate-chlorine relation graph obtained by observations in Yosa-naikai. (1950, III, 19; V, 10-12; IX, 30-X, 1)

Table I.

Name of Bay	Date	Name of River	Size of Sample	r	Fo	Level of signif.	Formula
Yosa-naikai	'50, III 19	Noda	20	-0.94	148.7	< 0.01	$[\text{SiO}_2] + 62.0 [\text{Cl}] = 1470$
	'50, V 10-12		27	-0.90	110.4	< 0.01	$[\text{SiO}_2] + 256 [\text{Cl}] = 4960$
	'50, IX 30-XI		20	-0.95	189.0	< 0.01	$[\text{SiO}_2] + 417 [\text{Cl}] = 5910$
	'50, V 10-12	Deeper stagnant water	19				$[\text{Cl}] = \text{const} = 16.35$
	'50, IX 30-XI		10	0.778	12.3	< 0.01	$[\text{SiO}_2] = 2680 [\text{Cl}] - 44100$
Kojima-Bay	'51, V 26-31	Sasagase	6	-0.91	19.30	< 0.05	$[\text{SiO}_2] + 443 [\text{Cl}] = 8530$
		Asahi	22	-0.97	301.5	< 0.01	$[\text{SiO}_2] + 438 [\text{Cl}] = 7574$
		Yoshii	6	-0.995	413.5	< 0.01	$[\text{SiO}_2] + 420 [\text{Cl}] = 6962$
	'52, II 26-27	Sasagase	25	-0.975	438.8	< 0.01	$[\text{SiO}_2] + 614 [\text{Cl}] = 11280$
		Asahi	22	-0.89	77.1	< 0.01	$[\text{SiO}_2] + 463 [\text{Cl}] = 9380$
		Yoshii	11	-0.99	514.3	< 0.01	$[\text{SiO}_2] + 542 [\text{Cl}] = 10660$

be regarded as constant. Accordingly the formula for deeper, probably stagnant, water may be shown as follows: $[Cl]=const.=16.35$. The third observation was made on the whole lagoon during the period from Sept. 30 to Oct. 1950. In this case, I collected only surface and bottom samples, but none from the middle layer. So I could not ascertain the depth of the silicate minimum layer. In order to pick up the deeper stagnant water samples out of the bottom layer samples, THOMPSON'S method of rejection was applied on them under 0.05 level of significance, and repeated until no sample was able to be rejected. The group of samples, thus sifted, may be considered to be of the deeper stagnant water and treated separately.

Kojima Bay: Kojima Bay is a narrow but long inlet bay situated on the northern coast of Seto-naikai, the Inland Sea, near Okayama. It is very shallow and poured by three rivers; Sasagase, Asahi and Yoshii, of which the first

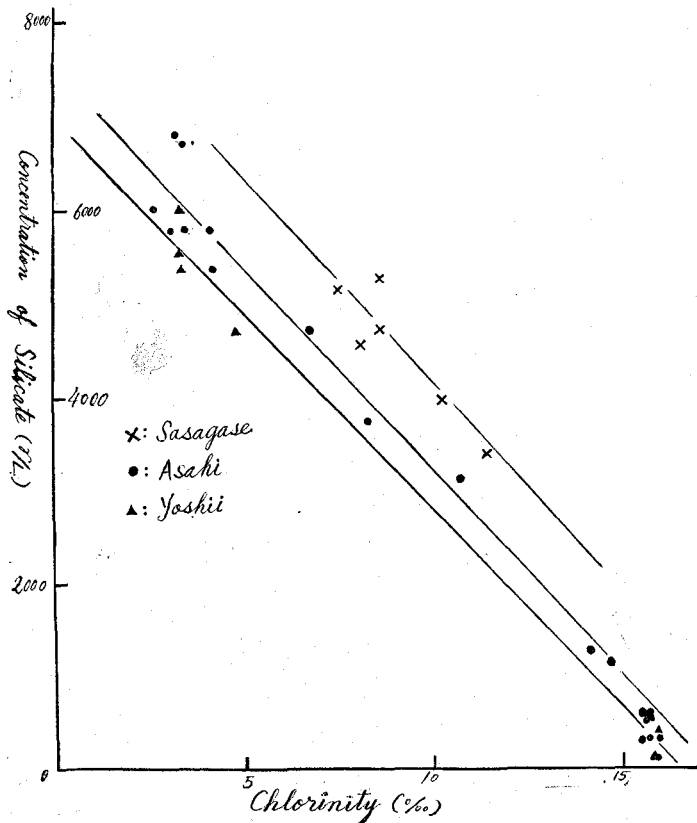


Fig. 4. Silicate-chlorine relation graph obtained by observations in Kojima Bay. (1951, V, 26-31)

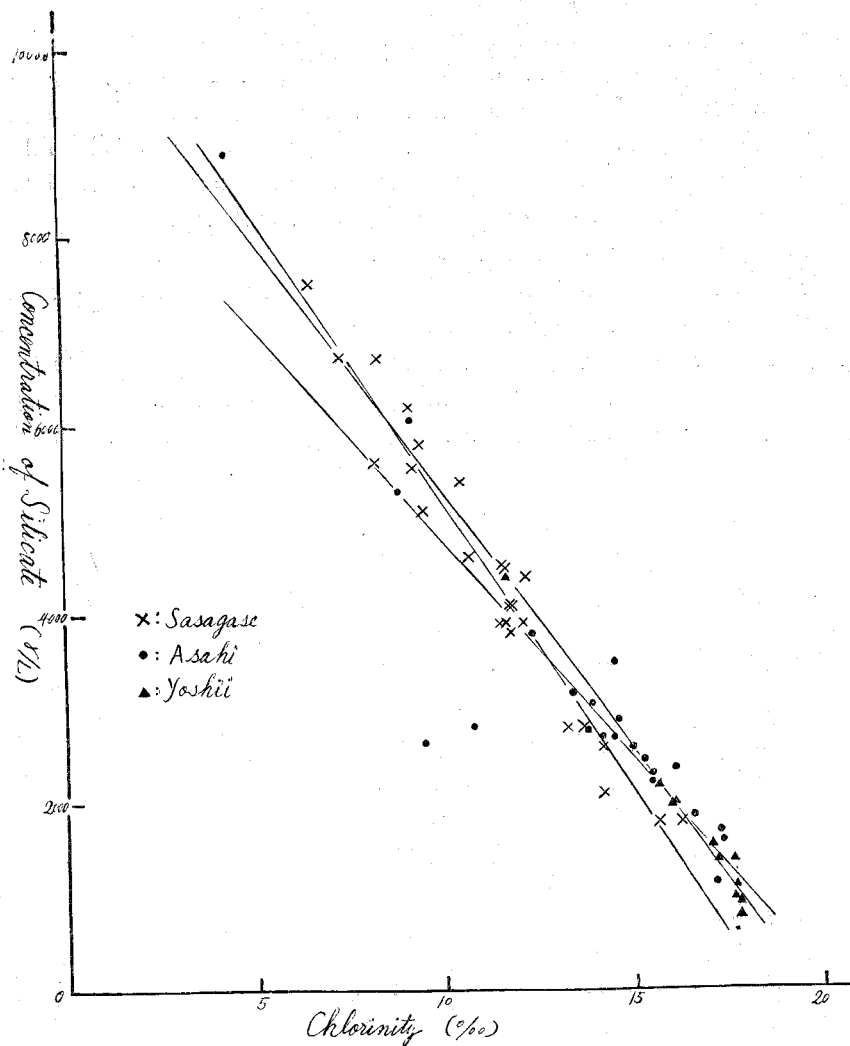


Fig. 5. Silicate-chlorine relation graph obtained by observations in Kojima Bay. (1952, II, 26-27)

one pours into the bay at the inner most part, the next at the central part of the northern coast and the last one near the mouth part of the bay. I tried the first observation during the period from 26 th to 31 st of May, 1951, and the second one during 26-27 th of February, 1952. In both cases, water samples were divided into groups judging from the situation of sampling stations and the distribution of slicks so that the water of each sample in a group is affected respectively by the same one of the three rivers.

Discussion and Conclusion

It is clear that high chlorinity indicates the characteristic of the sea water and high silicate concentration shows that of the river or stagnant water. Near the estuary, the river water stretches widely but only in very thin surface layer; thus the influence of river and that of bottom layer are easily distinguishable from each other. The relation of chlorinity and silicate concentration in all 9 observations, mentioned above, is represented by the formula $[\text{SiO}_2] + A[\text{Cl}] = B$ with considerable accuracy. The relation found in the stagnant bottom water must be shown by the other formula, of which the direction of the projected line on graph is nearly vertical, because the chlorinity is nearly constant in the bottom layer. Thus, in the survey of the region nourished by many rivers, we may be able to distinguish the affecting area of each river one another, at first by constructing the silicate-chlorine concentration formula on each group of samples which are judged, with the aid of the observation on slicks and the consideration on the distribution of sampling stations, to be affected by the same river and next by examining whether the concentration of silicate and chlorine of any sample in the region is in the range of values estimated from one of the formulae or not.

Coefficient A and B are not constant for a river, but show seasonal or occasional changes. Moreover, formulae for different rivers are not always provided each with characteristic values of A and B. It is not impossible that some formulae for different rivers show the similar value of A, B or A and B. Nevertheless, generally speaking the above-mentioned method seems to be one of the most convenient ones to settle the affecting area of a river in the sea where it pours in.

Summary

From 9 actual observations in two inlet bays, it is clear that the relation of the concentration of chlorine and silicate near the estuaries is represented by the general formula $[\text{SiO}_2] + A[\text{Cl}] = B$ with considerable accuracy. Here, the coefficient A and B varies seasonally and occasionally.