鹿児島湾に流入する河川の理化学的水質と生物学的水質

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Physical, Chemical and Biological Quality of Water from Rivers into Kagoshima Bay

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Abstract

The Kagoshima prefecture, wants to keep its beautiful Kagoshima-bay area for the next generations. The water of this closure-type bay shows the tendency to develop rich nutrients. Although the burden of COD in the bay increased, actually it decreases from 1992. However, the discharge of COD in the inner bay is still highest. In addition, the discharge of Nitrogen (N) and Phosphorus (P) increase. The influence of gray water and the fishery drainage of these causes are large. Three rivers that flowed into the inner bay were surveyed in this research. It is mainly emphasized on physical, chemical and biological quality of water. The correlations were examined based on these two-way findings. In addition, the PI and BI method along with the assessment are made for biological research on the collected samples of living things. The findings are reported in this paper.

Keywords : *phycical, chemical and biological quality, PI assessment*

1. Introduction

The Kagoshima bay is located at Kagoshima Prefecture in the southern part of Japan. This bay lies in North-south direction. The southern part connects with the open sea, east of China. Mt Sakurajima, is an active volcano and is located inside the bay. The eastern side of Mt Sakurajima is connected to the mainland by the volcanic eruption in 1914. Consequently, the seawater exchange to the enclave of inner bay area has become tranquil after all. This causes the spoilage of water in the inner bay area. In addition, water pollution due to the discharged rivers in this inner bay area from the rapid urbanization depraved this problem. The COD is found to be the highest in the entire Kagoshima bay area with 9.6 tons per day. The population growth of the head of a bay is especially large. This caused the damage to the fishery industry with the red tides.

The physical and chemical property of water quality was investigated in Shimizu, Koorida (branch of Amori river) and Inari rivers. Domestic gray water etcetera flow via these rivers into the bay. Therefore, the water quality investigations of these rivers were carried out. The investigations are focused on, physical, chemical and hydrobios. Hydrobios was collected by two methods, a Server-net and Porous concrete block (PoC). The hydrobios gathered by each method was classified according to the water quality parameter.

The evaluation of water quality uses two methods, a PI (pollution index) law and BI (living thing indices) law. In addition, a comparison is made for the consequence of the water quality survey and the hydrobios investigation. As a result, a strong correlation was found between water quality and hydrobios data.

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2. Biological survey

Changes of the river water due to the environment condition, is an effective method for the detail investigation on a specific living will lead to identify the quality index of water. The reality of water pollution is understood from the finding, and the distribution of the pollution source etc. In hydrobios, there is a benthic organism that becomes indices of the environment of the river. This benthic organism was gathered for investigation this time. The server net is used for gathering general hydrobios. The server net of $30cm^2$ is placed against the flow of the river, and all living things entering the net are collected. In other word, living things that live in the soil or sand in riverbeds including the shingle etc. are collected and the respective averages values of the place are taken.

In this study, two methods are used to collect hydrobios, they are, PoC block and the server net. The hydrobios gathered by each method was classified according to the water quality parameter. There are two water quality laws for evaluation, they are, PI and BI laws.

Each expression of PI and BI based on the classified hydrobios, and two kinds of assessments were made.

(a) PI method

The benthic organism is classified according to pollution index of the water quality, and method of doing the Environmental Impact Assessment of water according to the number of the style and population:

Si: Pollution step display of biological species

h: Occurrence frequency of living thing

PI shows the level of the water pollution of the water environment where hydrobios lives. The degree of the emergence is classified at three levels; few: h=1, abundant: h=2, remarkable: h=3. The contamination level is divided to four classes. Oligosaprobity: S=1 and β -mesosaprobity : S=2 and α -mesosaprobity: S=3 and polysaprobity: S=4. Pollution index (PI) is calculated from these by the following relationship:.

$$PI = \frac{\Sigma(Sih)}{\Sigma h}$$

(b) BI method

The benthic organism is classified according to pollution index of the water quality, by BI method the environmental impact assessment of water is made according to the number of styles.

A: Number of seeds not endured to pollution

B: Number of seeds endured to pollution

$BI = 2A + B$

3. Brief outline of investigation

(1) River outline

The environmental survey was made on three rivers, namely, Inari, Shimizu and Koorida river. The sampling water points in Inari river is marked as lower case alphabet a to g, Shimizu river with numerals, 1 to 5, and Koorida river upper case alphabet A-F. The rivers and sampling points are shown in Fig.1. Inari river is located at the eastern part of Kagoshima city. The water from Inari river is a drinking waters for the citizen living at down stream. Many food processing plants are located near the upstream area.

Figure 2 shows is an inflow of gray water in Shimizu river. Figure 3 shows the garbage thrown into the

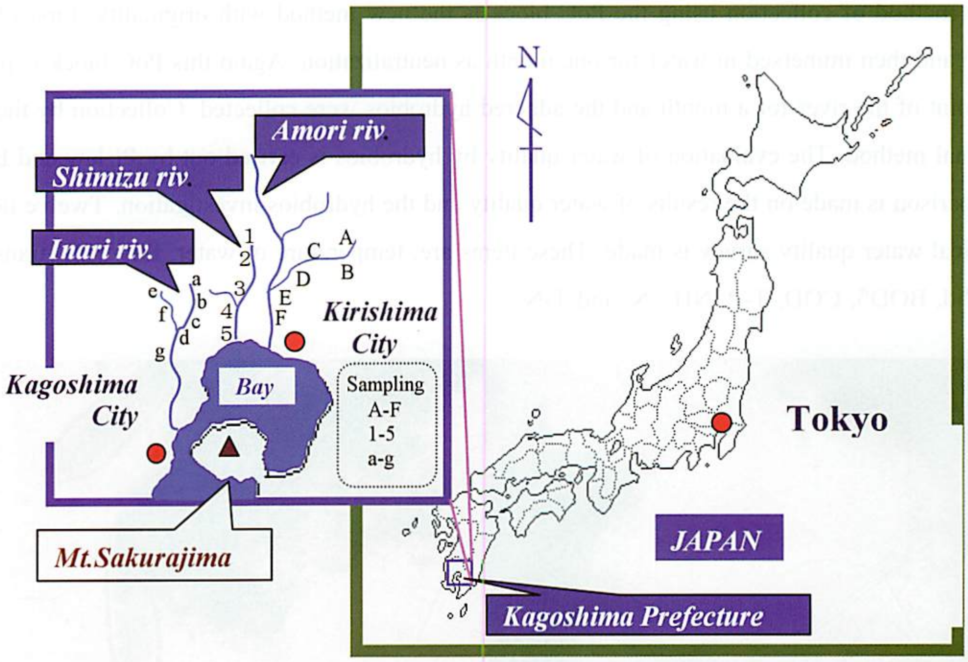

Fig. 1 Location of sampling points

Fig. 2 Gray water inflow to Shimizu River

Fig. 3 Garbage thrown into the river

river. Around 90% of untreated gray water flows into Shimizu river. Figure 4 shows the microorganism found near the exit of gray water. These become bodies of the filiform, and have cohesiveness. Paramesium lives mostly in dirt fluke ambient and is shown in Fig 5. Figure 6 shows the stones fixed with wooden frame for purification of edge water quality. Koorida river is a branch of the Amori river. There is a large meat processing factory nearby. The rapid urbanization advances toward these vicinity. Therefore, those influences are taken into consideration. The survey items for these rivers include physical, chemical and hydrobios investigation from 1996-2006. Hydrobios were collected by Server-net and PoC block methods for biological research. In addition, the hydrobios gathered by each method was classified according to the water quality parameter.

The method of collection using the PoC block is the new method with originality. First of all, the PoC block is made and then immersed in water for one month as neutralization. Again this PoC block is placed in sampling water point of the river for a month and the adhered hydrobios were collected. Collection by the server net is the conventional method. The evaluation of water quality by hydrobios is carried out by PI law and BI law. In addition, a comparison is made on the results of water quality and the hydrobios investigation. Twelve items of physical and chemical water quality survey is made. These items are; temperature of water, flow rate, transparency, pH, suspended solid, BOD5, COD, T-P, NH_4^+-N, and T-N.

Fig. 4 Micro-organism found near gray water

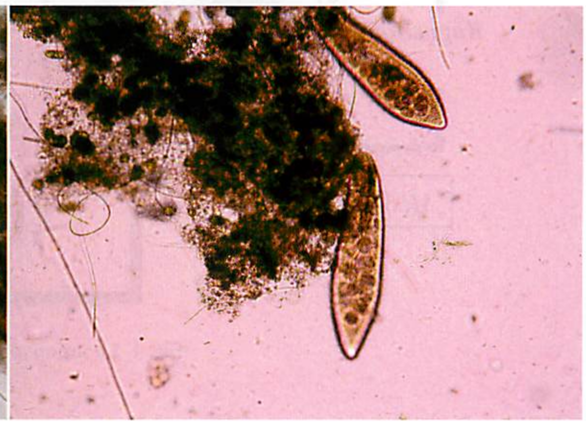

Fig. 5 Paramesium in dirt ambient

Fig. 6 Stones fixed with wooden frames

4. Results and considerations

(1) Physical and chemical water quality

Physical and chemical water qualities of water from three rivers for this research are shown in Table1. In the river, where the flow rate is low (0.18~0.52m^3/s), at the place near the downstream of the factory, BOD_5, COD, T-P, and NHH_4^+-N changed greatly. As for the water temperature of the river, the downstream temperature is two to three degrees higher than upstream. Sometimes in the summer, the temperature of river water rises up to 30 degrees. Figure 7 shows the comparison for the up stream and down stream water temperature for years 1999, 2000 and 2005, 2006. According to this, the water temperature of 2005, 2006 years rises. Especially, the rise of the water temperature at

Table 1. Physical and chemical properties of water

	Riv. I(u)	Riv. I(d)	Riv. S(u)	Riv. S(d)	Riv. K(u)	Riv.K(d)
Water temp.(℃)	14.5~16.5	12.5~2.4	15~21.5	13~24	17~22	17~26
Current vel.(m/s)	0.16~0.37	0.14~0.21		0.1~0.48		
Flow rate(m^3/s)	0.16~0.26	0.22~0.43		0.02~0.78	0.52~1.74	0.3~2.09
Transparency(cm)	100	50~100	98~100	70~90	100	84
COD(mg/l)	0.9~3.7	1.8~16.1	0.1~2.3	2.9~8.2	0.8~2.0	3.2
T-N(mg/l)	0~1	0.5~3.3	0~1.36	1~2.72	0.1~1.5	0.7
T-P(mg/l)	0.02~1.08	0.02~0.82	0~0.3	0.04~0.25	0~0.18	0.29

I: Inari, S:Shimizu, K:Korida (u): upstream, (d):downstream, T-N: total nitrogen. T-P: total phosphorous

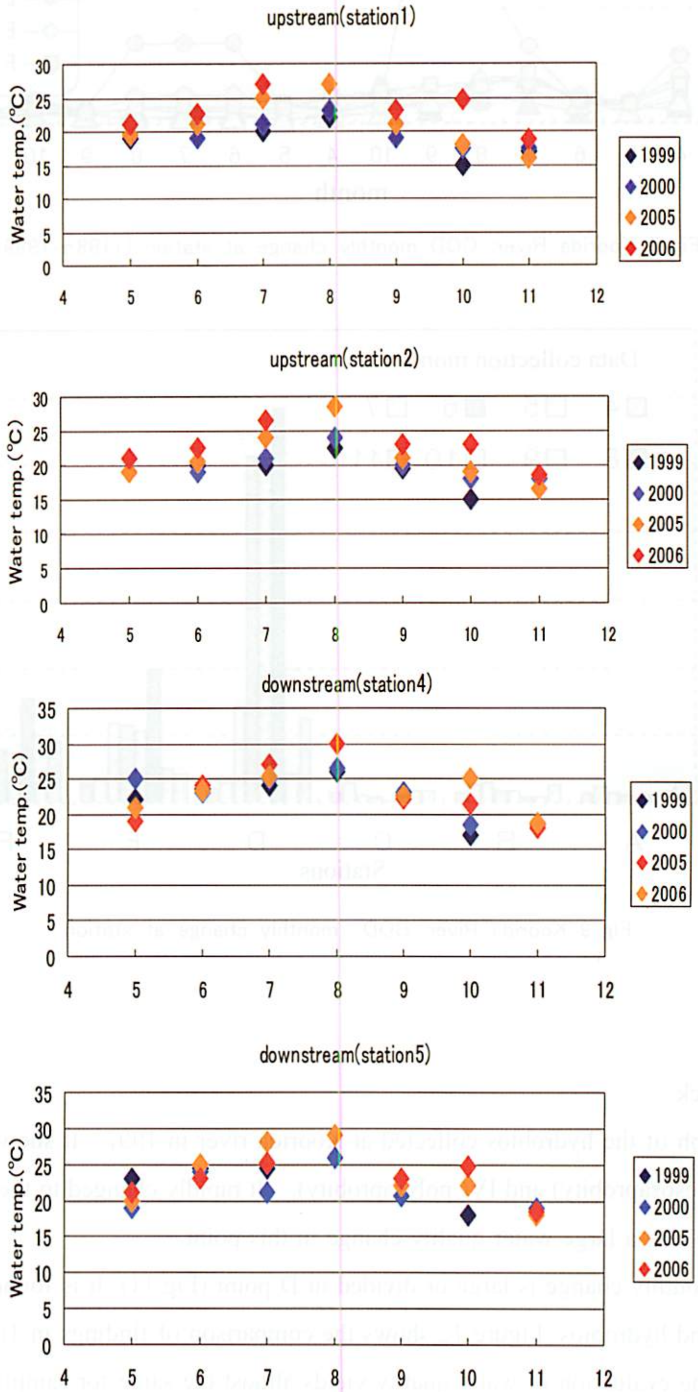

Fig. 7 River Koorida, water temp.(℃) monthly changes

lower flow rates is large. It is considered that the rise in temperature of 38 degrees from 36 is due to global warming. Figure 8 shows the monthly change at COD of Koorida river in the year 1998 and1999. At the D point, the influence of meat processing plant reached further down stream. Especially, in summer COD of D point rises considerably. Figure 9 shows the monthly change of BOD_5 of Koorida river. BOD_5 rises considerably as COD in water sampling point D.

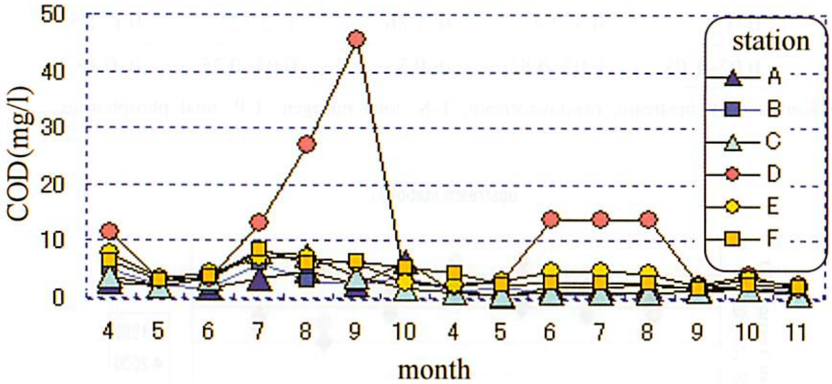

Fig. 8 Koorida River, COD monthly change at station (1198～1999)

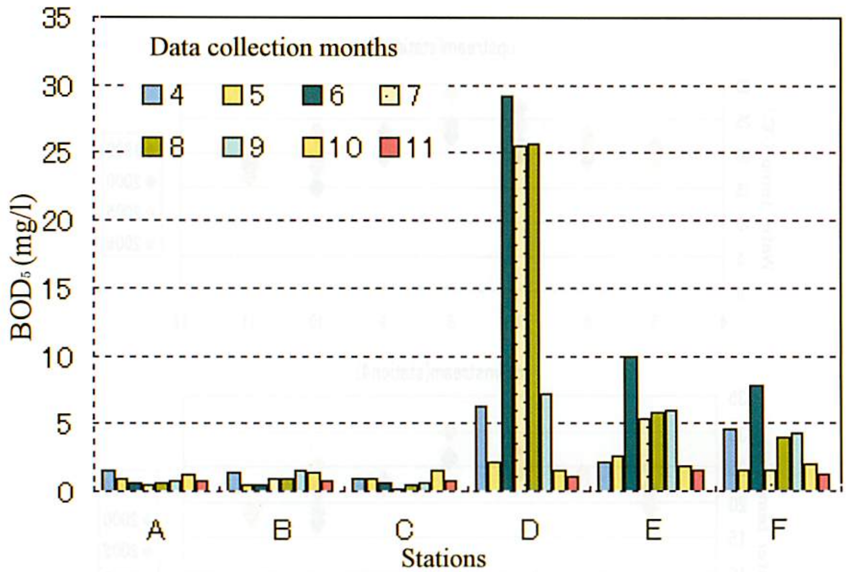

Fig. 9 Koorida River, BOD_5 monthly change at station

(2) Hydrobios finding

a) Collection by PoC block

Figure 10 shows a graph of the hydrobios collected at Koorida river in 1997. It shows I(oligosaprobity), II(β - mesosaprobity), III(α - mesosaprobity) and IV(polysaprobity). It rapidly changed to the polysaprobity in D point. It is considered that there was a large water quality change in this point.

Similarly, the BOD_5 monthly change is large or divided in D point (Fig.11). It is found that there is a good correlation between BOD_5 and hydrobios. Figure 12 shows the comparison of findings in 1999 on BOD_5, a PI assessment. In Koorida river, the evaluation of water quality yields almost the same for sampling points A to F.

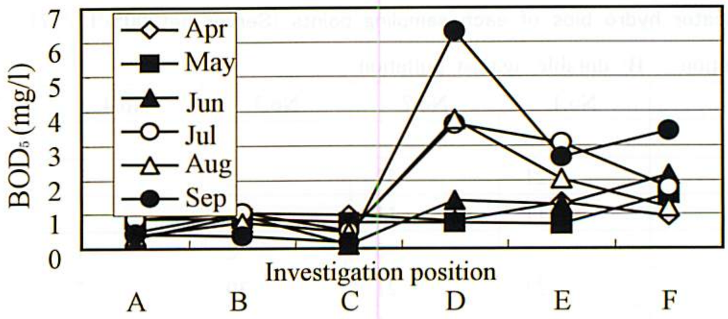

Fig. 10 Koorida River , BOD_5 monthly change at stations

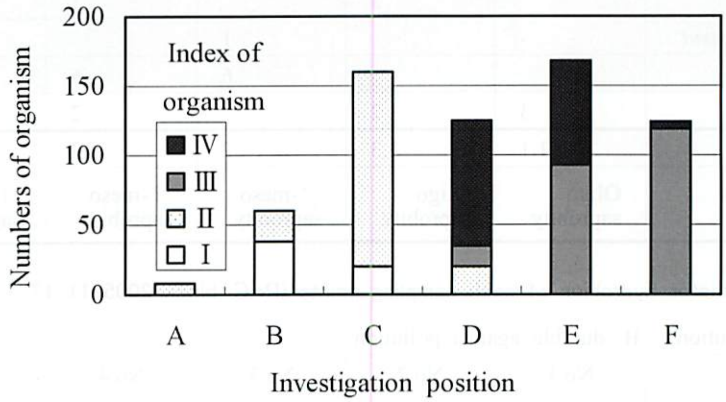

Fig. 11 Koorida river, Number of organism at stations (1997)

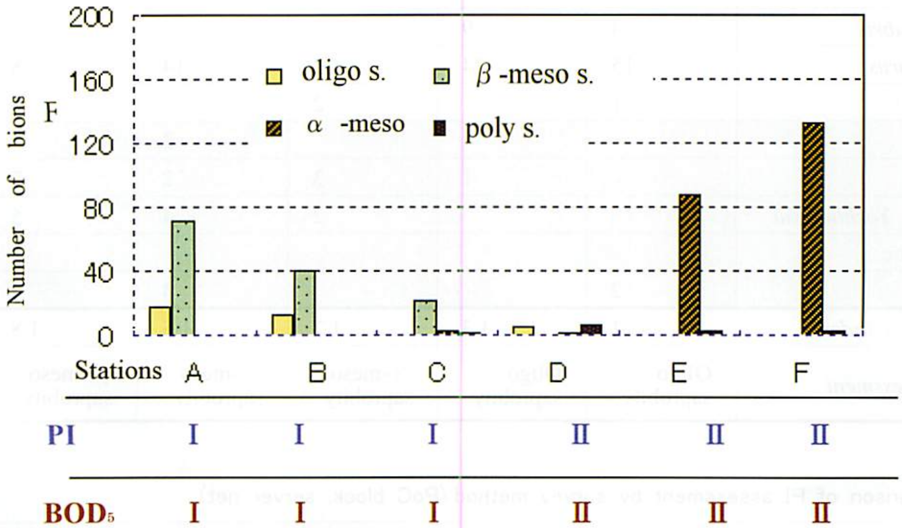

Fig. 12 Number of hydrobios habitat in PoC block (1999 May)

(b) Comparison of collection by PoC block and collection with server net

The indicator organism gathered by using server net is shown in Table 2. At the Koorida river, the samples collected at the respective sampling points shows the indicator organism and PI assessment. It is found that, the pollution starts from the sampling point C in the year 2005. The indicator organism gathered by PoC block is shown in Table 3. The PI assessment data shown in Table 2 and Table 3 are almost the same. The indicator organism gathered by server net and the one gathered by the PoC block show similarity in PI assessment is shown in Table 4.

Table 2. Number of indicator hydro bios of each sampling points (Server net2005/11/17)

A: weak against pollution　B: durable against pollution

Collection Point	No.1	No.2	No.3	No.4	No.5	
Hirata Ephemera	5					A
Ephemera	21	32	2			A
Width shrimp	11	11				A
Planaria lugubris		5	2	1		A
Rivurogammarus	23	21	39	7	10	A
Goera pilosa	1	1	2			A
Hill			1			B
Asellus		3		1		B
Chironomus Yoshimatsui			1		3	B
Tubifex tubifex			6	6	8	B
Others	3	2		2	1	
Pollution index	1.1	1.3	2	2	2.5	
PI assessment	Oligo saprobity	Oligo saprobity	β-meso saprobity	β-meso saprobity	β-meso saprobity	

Table 3. Number of indicator hydrobios of each sampling points (PoC block 2005/11/17)

A: weak against pollution　B: durable against pollution

Collection Point	No.1	No.2	No.3	No.4	No.5	
Hirata Ephemera	4		1	2		A
Ephemera	23	33	2		12	A
Width shrimp	6	12		1		A
Planaria lugubris	4	9				A
Rivurogammarus	15	24	32	14	8	A
Goera pilosa	1		2			A
Hill				2		B
Asellus		1	3	2	7	B
Chironomus Yoshimatsui			2	4	5	B
Tubifex tubifex						B
Others	2			3	1	
Pollution index	1	1.3	1.7	1.5	1.8	
PI assessment	Oligo saprobity	Oligo saprobity	β-meso saprobity	β-meso saprobity	β-meso saprobity	

Table 4. Comparison of PI assessment by survey method (PoC block, server net)

	PI	**No.1**	**No.2**	**No.3**	**No.4**	**No.5**
Server net	*PI(Pollution index)*	2	1.3	3.5	2.4	2.7
2005/10/15	*PI assessment*	β-meso saprobity	Oligo saprobity	α-meso saprobity	β-meso saprobity	α-meso saprobity
PoC.block	*PI(Pollution index)*	2	1.4	3.2	2.5	2.8
2005/10/18	*PI assessment*	β-meso saprobity	Oligo saprobity	α-meso saprobity	β-meso saprobity	α-meso saprobity
Server net	*PI(Pollution index)*	1.1	1.3	2	2	2.5
2005/11/17	*PI assessment*	Oligo saprobity	Oligo saprobity	β-meso saprobity	β-meso saprobity	β-meso saprobity
PoC.block	*PI(Pollution index)*	1	1.3	1.7	1.5	1.8
2005/11/17	*PI assessment*	Oligo saprobity	Oligo saprobity	β-meso saprobity	β-meso saprobity	β-meso saprobity

(c) PI and BI assessment

The PI and the BI assessment were made on hydrobios gathered by two methods of PoC block and server net. A comparison of these results from two assessments is shown in Table 5. As for the PI and the BI assessment, the accordance is hardly seen. This makes the BI assessment more difficult.

Table 5. Comparison of PI and Bi assessment

survey method: Server net

Sampling day	Index	Station				
		No.1	No.2	No.3	No.4	No.5
2005/6/21	*PI(Pollution index)*	1.1		2	3	3
	BI(biotic index)	8		8	2	2
2005/10/18	*PI(Pollution index)*	2	1.4	3.2	2.5	2.8
	BI(biotic index)	4	10	5	5	4
2005/10/19	*PI(Pollution index)*	1.1	1.3	2	2	2.5
	BI(biotic index)	10	9	13	6	5
2005/11/17	*PI(Pollution index)*	1	1.3	1.7	1.5	1.8
	BI(biotic index)	14	12	7	16	5

5. Summary

The finding can be summarized as follows.

Recently, there is an increase of the water temperature in these small and medium-sized rivers, and the increment is similar to that of upstream. Moreover, BOD_5, COD, and hydrobios, are greatly influenced by the industrial effluent when the flow rate is low. The active micro organism movement is seen at the exit of gray water. There is a benign correlation between a physical, chemical and biological water quality. Moreover, there is also a good correlation between BOD_5 and PI assessment.

There is also a favorable correlation between hydrobios collected by server net and PoC blocks. A considerable difference was found at PI and BI assessment. Finally, from this study, it is considered that the future PI assessment can be made readily and Fairly accurate.

鹿児島県における河川の理化学的水質と生物学的水質

鹿児島県はきれいな鹿児島湾を未来の子供たちに残すことを大きな目標としている。鹿児島湾は閉鎖水域を持つため富栄養化する傾向にあるため，これを防止することは美しい環境を未来に残すために重要な事である。近年の生活の向上に伴い，湾内の COD 負荷量は増加していたが，1992年から減少傾向に転じている。しかし，湾奥の COD 排出量は依然として最も高く，さらに，N や P の排出量は増加しているのが現状である。これらの原因は生活排水と漁業排水の影響が大きいと考えられる。

本研究では湾奥ゾーンに流入する 3 河川について調査を行った。主な調査は理化学的調査と生物学的調査の 2 つである。この 2 つの調査結果を基にこれらの相関性について検討し，良好な相関性を持つという結果を得た。さらに，生物学的調査で採取した生物について，PI 法と BI 法の 2 種類の評価法にて評価を行ったので，これらの結果について報告する。