

## Research on the Water Utilization for Agriculture in the Lower Basins of the Yodogawa River and the Yamatogawa River

Atsushi YOMOTA, Katsuhiko YABE and Sanji TEJIMA

Laboratory of Utilization of Water in Agriculture,  
College of Agriculture

### Introduction

Agricultural land extending over the lower basins of both the Yodogawa River and the Yamatogawa River has long been developed as main food production areas for the Hanshin region. The Yodogawa R. and the Yamatogawa R. themselves play an important role as main water resources for irrigation, especially for rice production. Many irrigation intakes have been constructed along both rivers by Government and private organizations. Agricultural land irrigated by the Yodogawa R. amounts to 3,623 ha and authorized intake discharge (so-called water right) is 16.8 m<sup>3</sup>/s, and with the Yamatogawa R., irrigated area and intake discharge are 1,619 ha and 9.4 m<sup>3</sup>/s respectively.<sup>1)</sup>

But recently, in accordance with the high rate of economic growth and unbalanced development between agriculture and other industries, agricultural land and the labor force have been absorbed by urban areas at a high rate. Consequently rural land formerly used as food production areas has been changing to urban land for industry and residence.

This phenomenon has great influence on agricultural management in this area. Unfavorable invasion of industrial and residential land into agricultural areas made it impractical for the continuation of agriculture and lowered local enthusiasm for farming. Moreover, agricultural areas are requested to reduce intake discharge from both rivers with the decrease in arable acreage.

To clarify this situation, the Government distinguished this area between Urbanization Promotion Area and Urbanization Control Area by promulgating a City Planning Law. Areas where land improvement work for agriculture had been carried out with Government investment were primarily designated to the latter category.

Under the circumstances mentioned above, our research was to study the tendency towards urbanization, the effect of urbanization on irrigation systems and the problem of water distribution for the remaining arable land.

This research was done by the staffs of Lab. Water Utilization in Agriculture, at the request of the Irrigation and Drainage Investigation Office for the Yodogawa Area, Kinki Regional Bureau of Agricultural Administration.

### Research Area and Research Methods

We restricted the research areas to arable land irrigated from the Yodogawa

R. and the Yamatogawa R., located in the lower basin of the Yodogawa R. downstream from confluent point of three rivers, the Kizugawa R., the Katsuragawa R. and the Ujigawa R. and also the Yamatogawa R. downstream from confluent point of the Ishikawa R..

We divided these areas into three blocks — right bank of the Yodogawa R., left bank of the Yodogawa R. and right bank of the Yamatogawa R.. The Neyagawa R. is the border line between the 2nd and the 3rd blocks.

We omitted the left bank of the Yamatogawa R. for the reason that this area has no water right on the Yamatogawa R. and depends for irrigation water on many farm ponds and small rivers in the area and the irrigation system is rather different from the above three blocks.

The water right on both rivers and recent acreage of land irrigated by each intake and name of concerned cities and towns by each block are shown in the Table 1. We call the three blocks, Mishima, North Kawachi and Middle Kawachi respectively.

To determine the general movement of agricultural management and to compare the features of the three blocks, we used some statistical publications which show the amount by city or town units, because of the difficulty to total the amount with the land irrigated.<sup>2),3)</sup> The figures for Farming Population, Acreage of Arable Land etc. mentioned in the following chapters are totals of

Table 1. Intake and Land Irrigated

Name of Intake	Intake Discharge	Land Irrigated	Name of City & Town Concerned
1 Right bank of the Yodogawa R. (Mishima)			
Takahama-hi	(0.051)	( 15 )	Suita
Goryo Pumping Sta.	2.15	608	Takatsuki
Mitsu-hi	(0.360)	( 82 )	Ibaragi
Doi-hi	(0.278)	( 70 )	Settsu
Kanmuri-hi	(0.506)	( 80 )	Shimamoto
Torigashita-hi	(0.955)	( 82 )	
Sangamaki Pumping Sta.	4.257	1,125	
Gokyu-hi	(0.333)	( 130 )	
Kawara-hi	(0.410)	( 70 )	
Sanzen-hi	1.088	90	
2 Left bank of the Yodogawa R. (North Kawachi)			
Kizushiro-hi	(0.040)	( 15.7 )	Moriguchi
Nakanoshiba Pumping Sta.	0.040	15.7	Hirakata
Taimano-hi	(0.005)	( 15.7 )	Neyagawa
Kishino-hi	0.033	10	Kadoma
Makino Pumping Sta.	0.322	60	Daito
Hirakata Godo-hi	(7.775)	(1,444 )	(Osaka)
Koya Pumping Sta.	7.775	1,444	

3 Right bank of the Yamatogawa R. (Middle Kawachi)			
Shirasaka-hi	0.0	} 645	Kashihara Higashiosaka Yao
Hasshaku-hi	0.694		
Niban-hi	3.790		
Sanban-hi	3.124	} 279	
Aochi-hi	1.041		
Ideguchi-hi	0.230		
Higashiura-hi	0.200	27	
Nagayoshi-Kawanabe-hi	0.140	105	
Uriwari-Nakayobi-hi	0.050	} 82	
Uriwari-Hichido-hi	0.030		
Uriwari-Komagatani-hi	0.040		
Sunjichohari-hi	0.050	42	
Yatabeyohsui-hi	0.060	28	
Yatakareki-hi	0.010	4	
Niwai-hi	0.030	4	
Karita-hi	0.190	25	
Jusangen-Horikawa-hi	0.500	70	

Name of Intake: upstream to downstream

Intake Discharge: m<sup>3</sup>/s, by water right

Land Irrigated: ha, in 1971

Figures in ( ) are included in main Intake

the cities and towns in each block. We also investigated the circumstances of land improvement works and the conditions of both rivers. Finally we surveyed the representative irrigation districts to know true situations of water distribution and farming.

As for Middle Kawachi, our Lab. performed detailed survey on similar subject, <sup>4)</sup> and for this reason, our field survey was emphasized on both sides of the Yodogawa R..

### General Movement of Agricultural Management

#### (1) Farming Population

Population engaged in agriculture in cities and towns that belong to this area in 1970 were 42,121 in Mishima, 35,010 in North Kawachi and 35,257 in Middle Kawachi. Ratios of these numbers comparing with those in 1966 are 85.8%, 87.0%, and 85.3% respectively.

#### (2) Farming Households

Numbers of farming households in 1970 were 8,365 in Mishima, 6,824 in N. Kawachi and 6,980 in M. Kawachi. Ratio of them comparing with those in 1966 are 88.6%, 86.5% and 85.7% respectively. Rate of reduction of farming households

is rather lower than that of farming population.

Next, from the stand point of size of holdings, there was little difference among three blocks. About half of the farming households belonged to the less-than-0.3 ha category and about quarter to the middle size of 0.3 to 0.5 ha in each block. But, for five years from 1966 to 1970, percentage of small sized holdings of less than 0.3 ha increased while large sized holdings of more than 0.5 ha decreased year by year. Real numbers in each category declined with the decrease in the total number of farming households.

### (3) *Part-time Farmers*

Ratio of part-time farmers in this district showed a very high percentage of 92.3 in 1970, of which 81.5 was the 2nd class part-time farmers engaged primarily in non-agriculture. Ratio of part-time farmers was high in N. Kawachi of 95.4 % and rather low in M. Kawachi of 86.3%. As for the total number, percentage of full-time farmers decreased from 13.1% in 1966 to 7.7% in 1970 and that of part-time farmers engaged primarily in agriculture also decreased from 19.6 % in 1966 to 10.8 % in 1970.

### (4) *Acreage of Arable Land*

Acreage of arable land in the three blocks in 1970 was 3,070 ha in Mishima, 2,487 ha in N. Kawachi and 2,422 ha in M. Kawachi. Comparing the figures with those in 1966, they had decreased to 81.8%, 79.6% and 82.1 % in each block. As for the conversion of agricultural land, we will mention later. Ratios of acreage classified into three categories as paddy field, upland field and orchard in 1970 were 95.6%, 2.6% and 1.8% respectively in Mishima, 94.5 %, 4.5 % and 1.0 % in N. Kawachi and 82.4%, 8.6% and 9.0% in M. Kawachi.

Comparing these ratios with those in 1966 showed little difference for each block. Percentage of paddy field was a little low and that of orchard was rather high in M. Kawachi.

According to this result, it is difficult to distinguish whether conversion of arable land was carried out equally from each category or conversion from upland field and orchard was covered by transfer from paddy field.

### (5) *Gross Agricultural Product*

To consider water utilization for agriculture, it is necessary to survey acreage by the kind of crop. But there were many varieties in the cities and towns, and tendencies or features were not uniform by each block. For the reason mentioned above, we surveyed the ratio of rice among gross agricultural product, as rice has the most important relation to irrigation. Average percentage of gross rice product in this district was only 31.8% in 1969, though ratio of paddy field in total arable land was more than 90%. Because, ratio of animal husbandry in gross product was very high in this district, we considered the ratio of rice in gross agricultural product except for animal husbandry which has little relation to acreage of arable land. In this case, ratios of rice product were 69.1 % in Mishima, 68.0 % in N. Kawachi and 27.9% in M. Kawachi.

It must be noted that low ratio of rice product in M. Kawachi, together with high ratios of upland field and orchard, showed the fact that highly productive agriculture was carried in this block.

With this reference, gross agricultural products per 10 a. in 1969, except for animal husbandry, were about 58,000 yen in Mishima, 75,000 yen in N. Kawachi and 118,000 yen in M. Kawachi.

Mar. 1974]

A. YOMOTA, K. YABE and S. TEJIMA: *Water Utilization for Agriculture in the Yodogawa & Yamatogawa River Basins*

11

Table 2. Farmers and Arable Land

Name of City & Town	Farming Population	Farming Household				Arable Land			
		Full-time	1st class Part-time	2nd class Part-time	Total	Paddy Field	Upland Field	Orchard	Total
Suita	5,733	36	18	1,043	1,097	263	23	12	298
Takatsuki	16,104	144	306	2,740	3,190	1,084	21	10	1,115
Ibaragi	13,937	181	289	2,416	2,886	1,134	30	11	1,175
Settsu	4,993	70	62	799	931	372	5	0	377
Shimamoto	1,354	12	29	220	261	82	2	21	105
Block total	42,121	443	704	7,218	8,365	2,935	81	54	3,070
Moriguchi	2,617	25	26	449	500	160	6	0	166
Hirakata	13,937	131	390	2,207	2,728	923	47	10	980
Neyagawa	8,586	78	184	1,414	1,676	511	43	15	569
Kadoma	4,223	45	149	648	842	372	3	0	375
Daito	5,647	34	51	993	1,078	383	14	0	397
Block total	35,010	313	800	5,711	6,824	2,349	113	25	2,487
Kashihara	4,740	229	222	515	966	170	10	214	394
Higashiosaka	15,674	339	370	2,348	3,057	937	94	1	1,032
Yao	14,843	390	294	2,273	2,957	889	105	2	996
Block total	35,257	958	886	5,136	6,980	1,996	209	217	2,422
Grand total	112,388	1,714	2,390	18,065	22,169	7,280	403	296	7,979

Farming Population and Farming Household: real number, in 1970

Arable Land: ha, in 1970

According to the fact mentioned in items (1) to (5), tendency of agricultural management in this district is summarized as follows; —

(a) Trend of decrease in farming population and households was slower than that in arable land. Acreage per farming households was decreasing and ratio of small holdings of less-than-0.3 ha was increasing.

(b) Ratio of part-time farmers was very high and agricultural income might have low priority in farmer's economy.

(c) Ratio of gross rice product in agriculture was rather low and upland crops and animal husbandry had high priority in this field.

These may be said as typical features of suburban agriculture in recent years.

### Aspect of Agricultural Land

#### (1) *Trend of Conversion in the Past*

Agricultural land in this area surveyed by Osaka Pref. in 1957 was 13,900 ha. From this figure, about 600 to 800 ha had been utilized for urban land every year. Acreage of arable land of 9,825 ha in 1966, mentioned in article (4) of previous chapter, diminished to 7,979 ha in 1970. Another example is a report by Osaka Pref. in 1957 which showed the acreage of 6,418 ha as irrigated from downstream of the Yodogawa R., while this figure decreased to 3,623 ha in a Government publication in 1970.<sup>1)</sup>

These facts showed that conversion of agricultural land in this district had been progressing at a very high rate of 4 to 5% a year.

#### (2) *Position of Agricultural Land in City Planning*

This area was designated as City Planning Area and was divided into Urbanization Promotion Area and Urbanization Control Area, on the 20th of June 1970. Table 3 shows ratio of agricultural land contained in each area.

Agricultural land designated as Urbanization Promotion Area may be converted in the near future, while if Urbanization Control Area remain, this will only total 3,873 ha or 7.6% of the total area. On the conditions mentioned above, it is very difficult to keep the agricultural system constant, and some drastic measures will have to be taken to encourage the agricultural management in the remaining arable land.

### Irrigation System in the Representative District

In this area, such land improvement works as Improvement of Irrigation & Drainage, Land Consolidation, Improvement of Agricultural Structure, Construction of Farm Roads etc. have been carried out by Osaka Prefecture and private organizations, under subsidies from the Government. Irrigation system in the representative district is as follows;

#### (1) *Takatsuki District*

This district of about 700 ha was irrigated from the Yodogawa R. through 5 intake gates as Takahama-hi, Mitsu-hi, Doi-hi, Kamuri-hi and Torigashita-hi, and holds water right of 2.15m<sup>3</sup>/s.

To improve the unfavorable condition caused by the lowered river bed and wornout irrigation facilities, Takatsuki Land Improvement Work started in 1967

Mar. 1974]

A. YOMOTA, K. YABE and S. TEJIMA: *Water Utilization for Agriculture in the Yodogawa & Yamatogawa River Basins*

13

Table 3. Position of Agricultural Land in the City Planning

Name of City & Town	City Planning Area	Urbanization		Urbanization Control Area	Agricultural Land sited in		
		Promotion Area	Control Area		Promotion Area	Control Area	%
Suita	3,660	3,660	0	0	422	0	0
Takatsuki	10,495	2,940	7,555	7,555	550	990	64
Ibaragi	7,516	2,062	5,454	5,454	597	933	61
Settsu	1,546	1,460	86	86	405	38	9
Shimamoto	1,682	298	1,384	1,384	67	34	34
Block total	24,899	10,420	14,479	14,479	2,041	1,995	49
Moriguchi	1,313	1,313	0	0	184	0	0
Hirakata	6,452	4,022	2,430	2,430	795	545	41
Neyagawa	2,400	1,932	468	468	442	248	36
Kadoma	1,221	1,137	84	84	256	70	21
Daito	1,805	1,181	624	624	370	81	18
Block total	13,191	9,585	3,606	3,606	2,047	944	32
Kashihara	2,477	915	1,562	1,562	219	456	68
Higashiosaka	6,178	4,985	1,193	1,193	1,122	158	12
Yao	4,126	2,715	1,411	1,411	850	320	27
Block total	12,781	8,615	4,166	4,166	2,191	934	30
Grand total	50,871	28,620	22,251	22,251	6,279	3,873	38

Area: ha, in 1971

by Osaka Pref., which covered an area of 608 ha of paddy fields belonging to Takatsuki City and Shimamoto Town.

The main project was the construction of new Goryo Pumping Station ( $\phi$  700 mm $\times$ 2,  $\phi$  400mm $\times$ 1) to stabilize intake discharge from the Yodogawa R. and replacement and rearrangement of 5 km of water canals to improve distribution system and to separate irrigation canals from those of drainage.

The irrigation plan was set to cover a probability drought of once-in-ten year and the irrigation period was from the 15th of May to the 20th of September. Unit duty of water was 13.9—17.1 mm/day on average and 18.9—21.5 mm/day maximum which was calculated by each category of soil. Water requirement for preparation of paddy field was 160 mm in 10 days. Total gross duty of water supplied by the pumping station was 2.15 m<sup>3</sup>/s, which contained 15% of conveyance loss.

Paddy field of 467 ha in total irrigated area was designated as Urbanization Control Area.

### (2) *Mishima-heiya District*

This district belongs to Shin-an Land Improvement District which in former times covered about 2,500 ha of paddy fields. Irrigation water was supplied from the Yodogawa R. and its two tributaries of the Aigawa R. and the Akutagawa R.. But water in the tributaries became unsuitable for irrigation because of unstable quantity and pollution.

Mishima-heiya Irrigation & Drainage Improvement Work operated by Osaka Pref. began in 1963 to improve irrigation and drainage systems in this district and ended completely in 1968. Irrigation water is completely supplied from the Yodogawa R. by the improvement of the Sangamaki Pumping Station ( $\phi$  800mm $\times$ 3). Irrigation and drainage canals were constructed to make separation of both systems possible. Irrigated area was 1,496 ha.

Unit duty of water was 15mm/day for well-drained paddy fields and 11mm/day for ill-drained and water requirement for preparation of paddy field was 120 mm and 100mm respectively in the preparation period of 20 days. Total gross duty of water was calculated as 4.14m<sup>3</sup>/s which consists of 3.45m<sup>3</sup>/s of total net duty and 20% of conveyance loss. Capacity of irrigation facilities was set in accordance with water right of 4.257m<sup>3</sup>/s.

577 ha in total irrigated area was designated as Urbanization Control Area.

### (3) *Yodogawa-sagan District*

This district is the largest on the left bank area of the Yodogawa R. covering 6,000 ha in the beginning of Showa Era and has a water right of 7.775 m<sup>3</sup>/s from the Yodogawa R.. In 1930, Hirakata Godo-hi (joint gate) was installed for the unification of 8 intake gates and Koya Pumping Station ( $\phi$  1,000mm $\times$ 4) was newly constructed in 1944 to cope with the lowered river bed.

Yodogawa-sagan Irrigation Improvement Work was carried out by Osaka Pref. from 1952 to 1960 to improve the above mentioned pumping station and 15 km of main irrigation canals. Moreover, from 1959 to 1970, Higashiosaka Agricultural Water Utilization Work was carried out by Osaka Pref. mainly to improve drainage facilities including the improvement of 1.5km of irrigation canals.

Concerning the drainage improvement by Higashiosaka Work, unit duty of water was corrected to 14mm/day for well-drained paddy fields and 13 mm/day



for ill-drained by an increase of 10% and 20% respectively. Conveyance loss was also added at 20%.

According to the above mentioned Yodogawa-sagan Project, irrigated area was 3,298 ha of paddy fields which belong to Hirakata, Neyagawa, Moriguchi, Daito, Kadoma and Osaka. Main part of them was designated as Urbanization Promotion Area, while at the most 200 ha in 5 separate blocks to Urbanization Control Area.

#### (4) *Tsukidome District*

This district was irrigated from the Yamatogawa R. through 4 intake gates as Shirasaka-hi, Hasshaku-hi, Niban-hi and Sanban-hi. Irrigation water was carried through the Tamakushigawa R. and the Nagasegawa R. to irrigate an area of 3,540 ha. This figure decreased in accordance with decrease of intake discharge caused by the lowered river bed.

In this district, Tsukidome Irrigation Improvement Work had been carried out by Osaka Pref., from 1955 to 1960, to improve irrigation canals. Irrigated area in above project totaled 1,317 ha belonging to 3 cities, Kashihara, Yao and Higashiosaka. Of which 65 ha was upland field and the rest paddy field.

Unit duty of water was classified into 5 classes from 8.5mm/day to 26.5 mm/day by soil and that for upland field was 3.2 mm/day. Water requirement for preparation of paddy field was 100mm in preparation period of 3 days. Total gross duty of water was 2.328m<sup>3</sup>/s.

A difficult problem was that the average droughty discharge in the Yamatogawa R. was 3.18m<sup>3</sup>/s and in that case, intake discharge was only 1.13m<sup>3</sup>/s. To solve this problem, such plans as to catch underflow and underground water, to pump up backwater from the Neyagawa R. and the Kusunegawa R., etc. were adopted.

The irrigated area nowadays has diminished to 650 ha of which at the most 200 ha was designated as Urbanization Control Area.

### **Problem and Consideration of Water Utilization**

#### (1) *Condition of 2 Rivers*

Discharge in the Yodogawa R. at Hirakata Gauging Station and in the Yamatogawa R. at Kashihara G. S. have been surveyed by the Ministry of Construction. From data taken from 1960 to 1969,<sup>5)</sup> we calculated average discharge through irrigation period as June to September and also the droughty discharge through the same period which we practicably determined as the 11th least discharge in 4 months. Table 4 shows the result.

As for the Yodogawa R., even droughty discharge is enough to supply irrigation water of 16.8m<sup>3</sup>/s as water right. On the other hand, in the Yamatogawa R., average discharge is still insufficient for irrigation, especially in August.

The next problem is a lowering of the river bed. In the past, most of intake facilities were improved by constructing pumping stations. However today, these pumps still can not be fully operated on account of the lowered river bed. Low-water works carried by the Ministry of Construction may spur this tendency.

At the same time, the problem of water quality occurs. Excessive Nitrogen injures rice yield.

#### (2) *Unit Duty of Water*

Table 4. Discharge in the Yodogawa R. and the Yamatogawa R.

Year	Yodogawa R.				Yamatogawa R.					
	Average Discharge			Droughty Discharge	Average Discharge			Droughty Discharge		
	June	July	Aug		Sept	June	July		Aug	Sept
1960	290.6	354.2	485.6	512.3	147.4	50.1	12.5	31.3	21.2	0.2
1961	536.0	899.8	286.1	227.8	117.2	72.7	21.9	4.8	17.8	0.5
1962	737.7	611.1	297.4	202.8	165.4	57.3	57.5	10.7	5.6	3.2
1963	667.4	312.6	265.6	206.4	174.6	22.7	6.9	7.7	9.5	3.7
1964	172.6	340.0	137.9	171.4	109.3	6.1	10.0	0.3	6.1	0.0
1965	550.4	749.4	168.7	786.8	128.3	62.1	44.9	5.0	86.5	0.4
1966	416.4	538.6	199.4	313.4	154.2	25.0	72.1	13.2	22.7	1.3
1967	138.1	514.6	142.7	155.4	112.7	0.7	42.2	5.9	13.8	0.0
1968	181.6	496.9	419.3	377.1	163.0	—	—	—	—	—
1969	369.9	750.8	271.0	187.3	150.2	—	—	—	—	—
Ave.	406.1	556.8	267.4	314.1	142.2	37.1	33.5	9.9	22.9	1.2

Discharge: m<sup>3</sup>/sDroughty Discharge: the 11<sup>th</sup> least discharge from June to September

In this article, we will consider whether decrease of irrigation water is proportional to decrease in acreage of paddy fields at the phase of unit duty of water.

It is considered that unit duty of water for paddy fields may increase because of the following reasons;

- (a) separation of irrigation and drainage and reformation into well-drained paddy fields
- (b) lowering of ground water level caused by conversion of neighboring fields
- (c) also lowering of ground water level caused by invasive factories using ground water
- (d) decline in rate of repeating use of water, or reduction of return flow, owing to the separation of paddy fields caused by sprawling

Detailed survey to support above conjecture was not done. But some survey on unit duty of water showed the average of 17.1 mm/day and the maximum of 22.0 mm/day in Mishima-heiya which are rather larger than that planned in Mishima-heiya Irrigation & Drainage Improvement Work mentioned in article (2) of previous chapter. Water requirement for preparation of paddy field is 150mm to 120mm in above Work. According to our survey in Mishima-heiya, preparation period becomes short with increase on utilization of rice planting machines and increase of part-time farmers who engage in agriculture especially on Saturday and Sunday — 28 days in 1967, 20 days in 1969 and 15 days in 1970. And it is guessed that this may shorten to 1 week in 1975. Much more water will be required in the short preparation period.

We will try to calculate net duty of water in preparation period with the example of Mishima-heiya, by considering the decreasing irrigated area as 1,125 ha in 1972, same net duty as 13mm/day, shortened preparation period as 10 days and increasing preparation water as 150mm.

$$1,125 \times \left( \frac{9}{10} \times \frac{0.013 \times 10,000}{86,400} + \frac{1}{10} \times \frac{0.150 \times 10,000}{86,400} \right) = 3.50 \text{ m}^3/\text{s}$$

The result is a little larger comparing with the maximum net duty of 3.45 m<sup>3</sup>/s planned in Mishima-heiya Work, despite the decrease of irrigated area from 1,496 ha to 1,125 ha.

### (3) *Quality of Irrigation Water*

Recently, water quality in the Yodogawa R. and the Yamatogawa R. has caused problem. Some surveys concerning water quality have been done in this area.

In the particular case of Yodogawa-sagan and Tsukidome Districts, main irrigation canals run through factory and residential areas. Consequently drainage from factories and residences flows into these canals. Irrigation water is rather helpful for river maintaining flow, but the agricultural area is suffered from pollution. In case of Yodogawa-sagan District, irrigated areas sited in Urbanization Control Area, where agricultural management must be promoted, is unfavorably located downstream of main irrigation canals. Injury on crops may be accelerated if irrigation water is forced to reduce its discharge with decrease of arable land.

The following Table shows the example of change of water quality from intake to downstream.<sup>6)</sup>

Table 5. Example of Pollution in Yodogawa-sagan District

Item \ Site	Koya Pumping Station	Higashiosaka	Nishisansyo
P H	7.0	7.3	7.3
T-N (ppm)	0.69	9.83	11.98
COD (ppm)	4.38	19.12	51.9
S S (ppm)	31.6	60.3	77.9
E C ( $\mu\Omega$ )	0.10	0.33	0.42

P H—Potential of Hydrogen

T-N—Total Nitrogen

COD—Chemical Oxygen Demand

S S—Suspended Solids

E C—Electric Conductivity

Higashiosaka is the eastern part of irrigated area of Yodogawa-sagan District and

Nishisansyo is the western part of the same District

#### (4) *Water Utilization in the Future*

Our conclusion on water utilization for remaining arable land in the future is as follows.

Agricultural land in Mishima-heiya and Takatsuki Districts must be prevented from sprawling for the following reasons;

- (a) land improvement works have been carried out
- (b) this area is designated as Urbanization Control Area
- (c) arable land is collective and highly productive
- (d) farmers are enthusiastic for agricultural management
- (e) green tracts must be remain from the stand point of City Planning

First, it is necessary to ensure intake discharge from the Yodogawa R. through the irrigation period, along with the rearrangement of water right based on actual conditions. Next, perennial irrigation must be taken into consideration to promote secondary cropping, which is essential to the proper agricultural management.

As to the left bank area of the Yodogawa R. and the right bank area of the Yamatogawa R., the trend to urbanization of arable land is highly prominent and most of the area is designated as Urbanization Promotion Area. Conditions have become unsuitable to continue agricultural management and consequently farmers in this area are not so enthusiastic. In Yodogawa-sagan District, for example, it is almost impossible to prevent irrigation water for the remaining arable land from pollution. Under the circumstances mentioned above, conversion of agricultural land may be prompted and at the most 200 ha from the area designated as Urbanization Control Area, if Government and farmers themselves are eager to keep agriculture, it is better to convey irrigation water directly from the Yodogawa R. through pipe line, gross duty of water may be  $0.5 \text{ m}^3/\text{s}$  assuming unit duty as 20mm/day.

### Summary

Such figures as prominent rate of conversion of agricultural land, high ratio of part-time farmers etc. show the trend to urbanization in this area. Also we can see prominent progress of sprawling on occasion of this field survey.

Ratio of agricultural land located in Urbanization Control Area is only 7.6% of this area.

For the paddy fields in urbanizing area, it is almost impossible to prevent irrigation water from pollution.

As to the right bank area of the Yodogawa R., land improvement works have been carried out, and arable land is recognized to be collective and highly productive.

With this area, it is necessary to ensure intake discharge from the Yodogawa R. including perennial irrigation.

### Acknowledgement

The authors wish to express their thanks to the staffs of the Irrigation and Drainage Investigation Office for the Yodogawa Area, Kinki Regional Bureau of Agricultural Administration.

### References

- 1) Economic Planning Agency of the Prime Minister's Office : Survey Report on the Yodogawa, Yamatogawa and Kinokawa River Systems, 1970
- 2) Osaka Prefecture: Statistical Yearbook of Osaka, 1966-1970
- 3) Osaka Prefecture: Survey Report on the Substantial Movement of the Agricultural Land in Osaka, 11-14, 1971
- 4) Lab. Utilization of Water in Agriculture, Univ. Osaka Pref.: On the Durability of Agriculture in the Neighborhood of Great City, 1967-1969
- 5) Ministry of Construction: River Discharge Chronology, 1960-1969
- 6) Kinki Regional Bureau of Agricultural Administration & Osaka Prefecture: Survey Report on the Quality of Agricultural Water, 98, 1972