

# *Water Recycling in Japan*

## **Water Resource Group**

Shoko Ashikaga

Mika Aoyagi

Ritsu Hiroe

Naoki Nishimura

Yohei Kudo

***Chapter1. Water Resource in the world***

***Chapter2. The importance of Water Recycling***

***Chapter 3 Why Water Recycling increased rapidly in Japan?***

***Chapter4. Conclusion***

***Chapter5 Annex***

## ***Chapter1 World Resources in Japan***

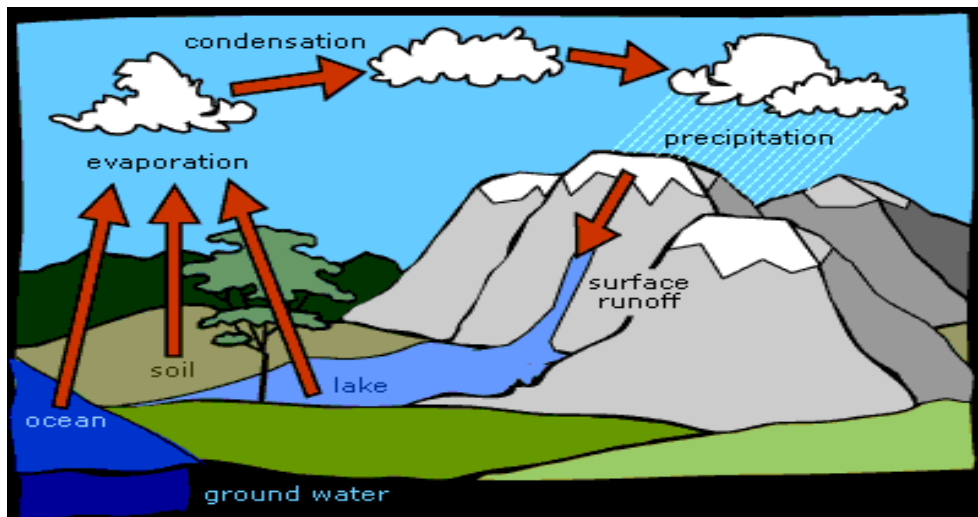
In chapter 1 we will explain “water resource in the world”.

This part consists of the following three topics.

- 1, What is water resource?
- 2, What is happening to water ?
- 3, Two examples of water shortage problems

### **1, What is water resource?**

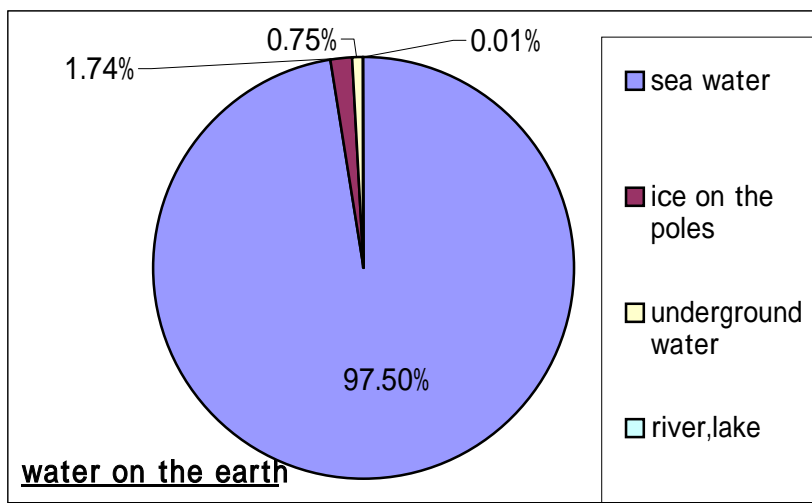
What do you think water resource is?



**1-1 several kinds of water**

In this illustration(1-1), you can see several kinds of water. Water in the sea, lake, and underground water and so on. But not all of these kinds of water are called water resource. In fact, not all of water we usually see around us is water resource. Water resource is not water we can see, but water we can use.

Then, how much water resource is there on the earth? We tend to consider there is enough water on the earth and call the earth "planet with much water". However, it is not true. Please look at the pie graph(1-2).



## 1-2 how much water resource is

In fact, 97.5% of water on the earth is in the sea and, fresh water consists of only 2.5 %of the water on the earth. Fresh water is water without salt. However we cannot also use water in ice poles and underground water directly. Therefore, what we can call "water resource" is only 0.01%.of the water on the earth. It is in the river, lake and so on.

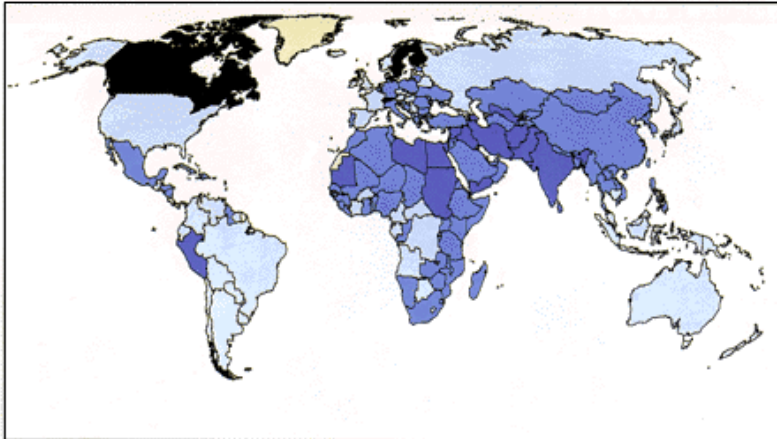
We tend to consider we have unlimited amount of water. However we should know that water is a very precious resource.

## 2 , What is happening to water ?

Now we have many problems concerning water resource in the world.

Since Japan is a country abundant in water, we rarely feel we have problems about water resources. However we have to recognize that the number of people who are suffering from water shortage is much larger than we imagine.

It is as many as 1,700,000,000 people who are suffering from water shortage in the world. Please look at this picture(1-3). People in the dark blue countries are under serious water shortage. The blue countries have less serious water shortage. The light blue areas are countries where water shortage is not so serious. The black areas are very lucky countries with no water shortage. The white countries are not investigated yet. Now, you understand many countries all over the world are suffering from water shortage.



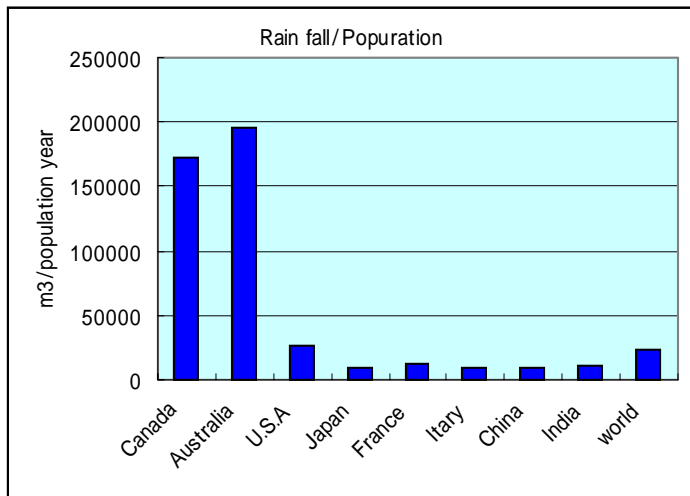
### **1-3 water shortage in the world**

The other day, "IPCC"(Intergovernmental Panel on Climatic Change) reported that water shortage will get worse by global warming and 5,000,000,000 people will suffer from water shortage in 2050. The world population is estimated to be about 8,000,000,000, by that time and more than half of the population will face water shortage problems.

Much water is need in agriculture. Do you know how much water do we need to grow 1 kilogram of wheat. The answer is 1 ton of water. Also, do you know Japan imports 70% of food from foreign countries? It means that Japan is consuming much water of the world indirectly. So we have to regard water shortage in the world as our big problem.

#### **Two examples**

I have written about what is water resource and what is happening to the world. I am sure you have understood how precious water resource is.



#### 1-4 difference of water resource in the world

In the picture(1-4) , you can see that various areas have different amount of rainfall. This is one of the reasons of water shortage in many areas. However at the same time, in some areas, water shortage is caused by human beings. Next, I will explain two cases of water problems in the world; 'Aral Sea' and 'Turkey and Syria'

#### 1 Aral Sea

The Aral Sea was 4th largest lake in the world surrounded by Kazakhstan and Uzbekistan in Central Asia. But it is getting smaller and smaller in recent years. (1-5)



#### 1-5 Aral Sea

Please look at this picture (1-6) below.

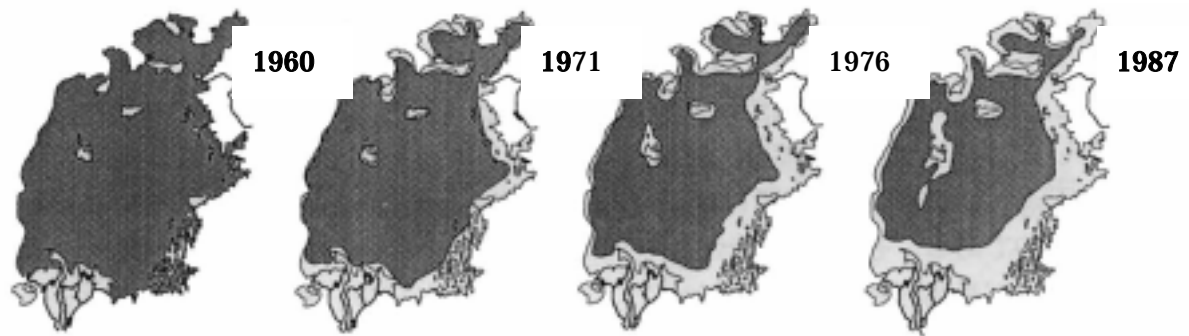


### **1-6 ships on the ground**

You can see ships on the ground. But they were once in the sea. The seawater decreased and there is no water under these ships.

Please look at this picture (1-7) and graph (1-8). You can see that the sea is getting smaller and smaller. The amount of water in the sea began to decrease in the 60s, and reduced to 1/6 of entire sea in the 80s. The water level fell by 14m from 60s to 90s. The salt concentration of Aral Sea rose, and the fish in the sea exterminated.

It became difficult for people to get water from the sea.



year	level of sea(m)	width of sea	amount of water (km <sup>2</sup> )	rate of salt (%)
1960	53.41	68000	1090	10
1971	51.05	60200	925	12
1976	48.28	55700	763	14
1987	40.5	41000	374	27
2000	33	23400	162	35

**1-7 1-8 Aral Sea**

Why is this happening? It's because of the development by humans. After World War 2, the Moscow government tried to grow cotton trees near Aral Sea and used too much water. They used almost all water in the rivers before it flows into the sea.

This is how human beings caused water shortage around the Aral Sea. We should be very careful about how to use water, shouldn't we?

**2, Water Dispute between Syria and Turkey.**

Please look at the picture (1-9). These countries are Turkey and Syria. Euphrates River runs through these two countries.





## 1-9 Turkey and Syria

Nine years ago, Turkey built the Ataturk Dam using 48,000,000,000 tons of water from Euphrates River .

Owing to the dam, the wheat production of Turkey increased by three times.

However Syria began to suffer from water shortage and the wheat production of Syria dropped to half.

Suddenly water became precious in Syria. Some people began to sell the water in the country.

To solve water shortage problem in Syria, Turkey and Syria made an agreement, which stated Turkey would give 500 tons of water to Syria.

Although the agreement was reached, Syria has been protesting that Turkey would not give 500 tons of water to them.

Now Syria is suffering from water shortage, and people are afraid that there will be a war between the two countries.

In chapter 1, I have written about water resource in the world. I hope you understood ) how precious water is.

In the following chapter, we will explain water recycle in industrial field in Japan.

I will explain the reason why we will mention about it.

There are three types of water usage. Water used for agriculture, living, and industry.

We think that water used for agriculture and living is directly linked to our lives. For example, we can not live without eating and drinking. So it is difficult to decrease the amount of water used for agriculture and living. On the other hand, we think water used for industry is not directly linked to our lives.

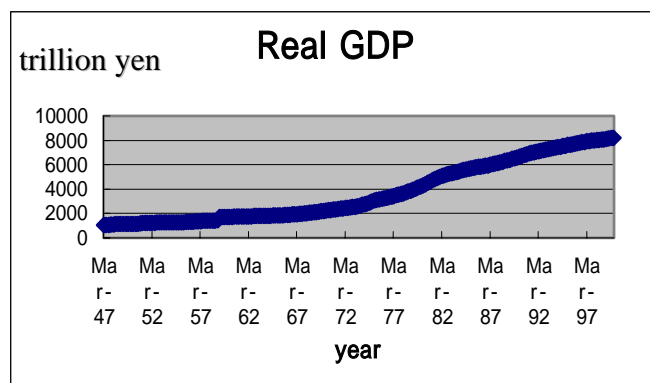
Therefore we will focus on water used in industrial field, especially water recycling<sup>1</sup> in Japan.

## Chapter 2

As we described in Chapter1, amount of the water to use is increased with the growth of economy. In the past, Japan has experienced the period of the rapid high economic growth which we had from 1958 to 1973. In that time, we can think the water shortage could happen because of the rapid economic growth, but it didn't. People were not so much influenced by this possible water shortage and economy also wasn't affected. In this chapter, we want to show that water recycling greatly acted on the factor which promote the economic growth without falling Japan in to water shortage. First, we are going to explain the relation of the economic growth and the water demand for showing that the water demand in Japan with afforded by using recycling water.

### The economic growth and water demand

As economy has grown since 1960's especially GDP has grown. In that period, it doubled and by now it is 4 times as before. (2- )



2- ) the change of real GDP in Japan (Keio data bank)

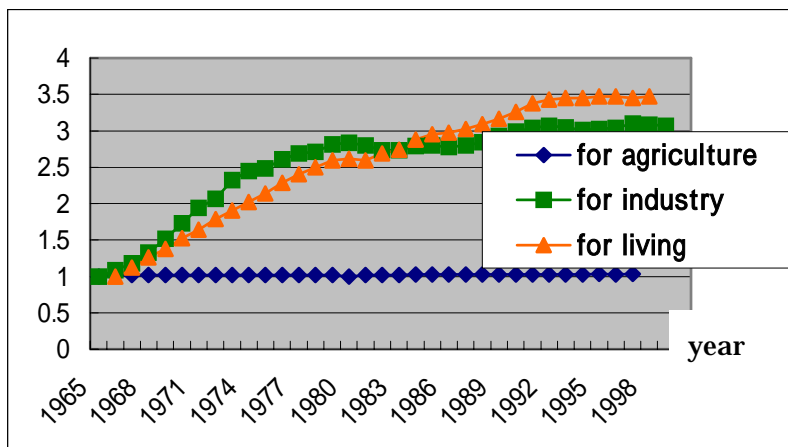
### The increasing of water use

The amount water used in agriculture has not been so much changed. Then we need to pay attention to the water demand for industry and for living. Please see the figure 2-

<sup>1</sup> Water recycling means to use again which was used once in factories.

.The water for industry has 3 times increased in this 35 years, and also the water for living, 3.5 times. So what is the factor for these increasing of water demand?

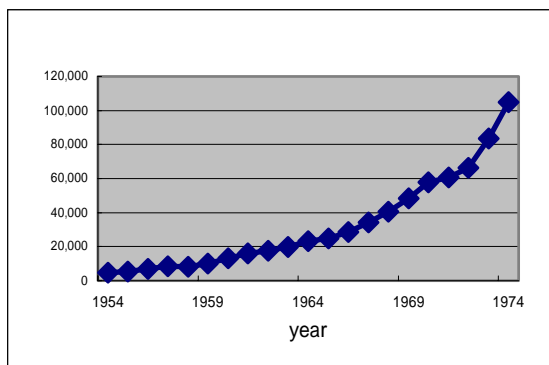
2- ) the increasing rate in 3 fields (Ministry of Environment)



**The factor to increase water demand**

Well, first we can point out the growth output in industry. In that area, the growth of the output is remarkable and it has about 10 times increased in the period of high economic growth.

And we can use the much water to produce. So it means increasing of water demand.



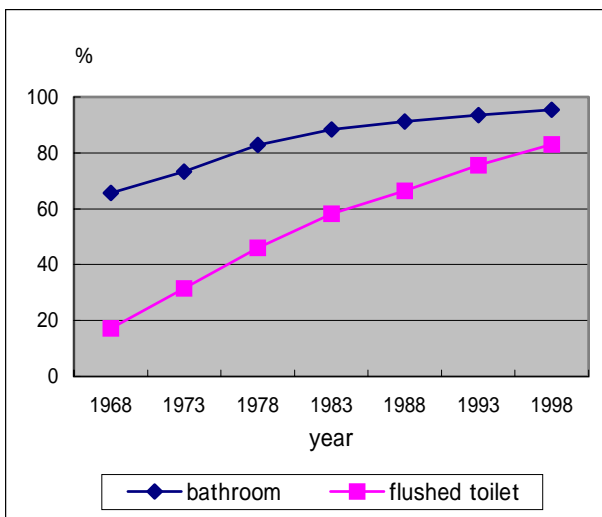
2- ) the change of sum of output in industry

And water demand for living was increased remarkably. Because of the increasing in the population and increasing of the amount of the water for use per one person.

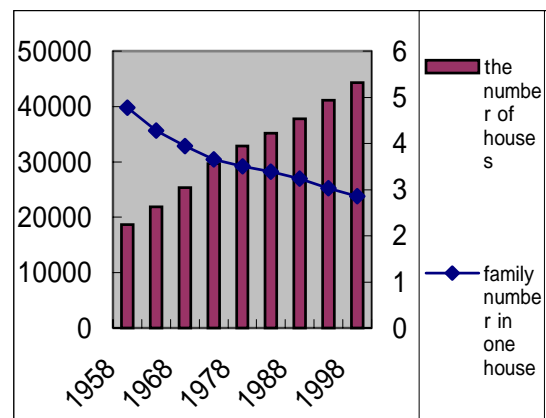
Population has been increased rapidly 3.5 times in these 40 years. and with economic growth, the living standard was improved and our life style has changed. Therefore the amount of water to use per one person increased.

As a big causes of increasing water used for living per one person, we think of the increase in the rate of bathtub and flushed toilet possession, and the increase in the number of house holds.

According to the data of Tokyo, water use at home is set to an average of 250L now. And we use 65L of water for toilet and 60L for bath. So we consider that the increasing of these 2 factors affected the amount of the water use greatly.



2- )the change of the rate of bathroom and flushed toilet possession  
(The housing and estate white paper)



2- )the change of the rate of the number of houses and number in one house  
(the housing and estate white paper)

Although, we mention that the amount of the water use also changed by not population but by the number of the households. For example, the amount of water for cooking, washing and taking bath increase with decreasing of the number of family in a household. In living alone, the amount of water used about 1.5 times per one person compared with the 6 persons family. The number of households has increased, as figure 2- .

As that reasons, it turns out that the demand of water increases with the economic growth. However in Japan, People were not so much influenced by this possible water

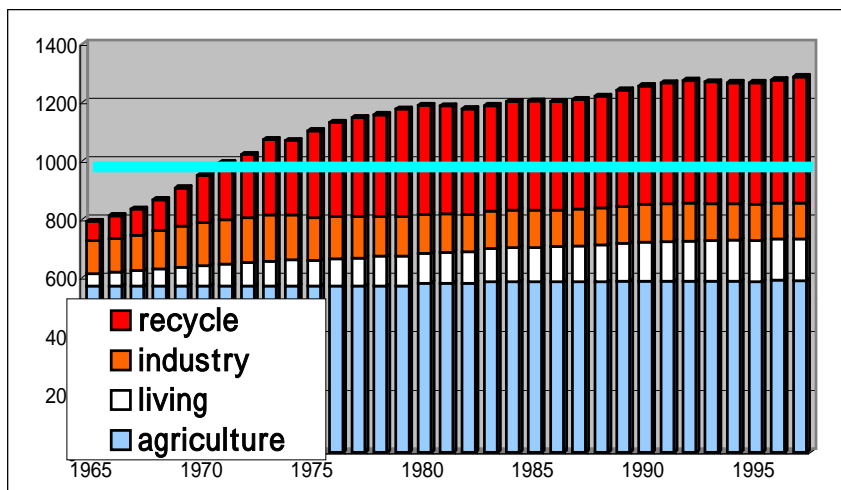
shortage and economy also wasn't affected. I think you can understand by the figures we saw in this chapter. But, there is not so much water in Japan. Compare with foreign countries, rain falls not so much in Japan. And particular to Japan, agriculture has much right to use water as vested right. (We explain that in annex in detail.) so water used for industry and living is less than the amount of the water that there are in Japan.

Then, recycling water played great part in problem of water resources in Japan.

I want you to see the figure 2- . The actual amount of the water use is the portion of industry, agriculture and living. And if using of recycling water was not advanced, amount of the water use in Japan had increased about 1.5 times. This is a huge amount.

And also, if it didn't advanced, water demand would exceeded the limit of water supply.

2- ) the amount of water of each fields



(Ministry of Environment and Ministry of Land, Infrastructure and Transport)

Now, we think the limit of water supply, which is amount of water supply when we get all dams that Japan plan now. Because, we think it does not certain that all dams planning now are completed, and though it completed, we think dams will not make more than this. Because, in one hand, development of dams progressed favorably and has increased supply, the other hand, development is too much now, efficiency of using gets worse and suitable place for dams is decreased.

Therefore if the limit of water supply, which is amount of water supply when we get all dams that Japan plan now, the amount is 99.7 billion m<sup>3</sup>(we draw the line in

<sup>2</sup> We use the date of Water Plan21 written by Ministry of Land, Infrastructure and Transport. and we

figure.) and the economic growth might be stagnated by water shortage since 1971. since the year, water demand exceeds limit of water supply.

As the reasons, we can say that it was indispensable to use recycling water in Japan in the time of great economic growth.

### ***Chapter 3 Why Water Recycling increased rapidly in Japan?***

Water Recycle Rate increased rapidly in Industry in 1970s in Japan.

So, Why Water Recycle Rate increased rapidly in 1970s?

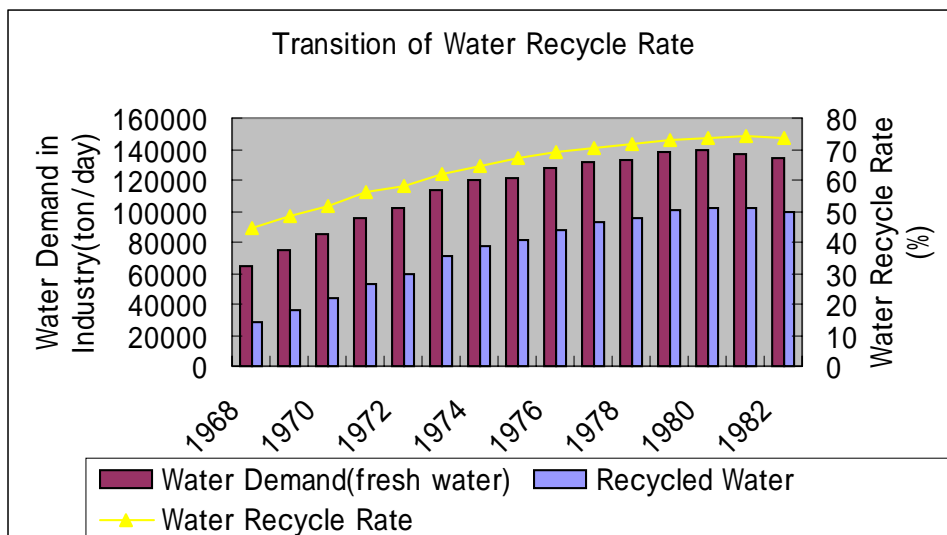
It is because of increasing of Water Charge in Industrial Water Way. In Japan, rising of Water Charge promoted Water Recycle.

#### ***1. Water Recycle increased rapidly in Industry in 1970s.***

Water Recycle is increasing in Industry in 1970s.

Please look at the graph 3-1. The right vertical axis expresses Water Recycle Rate and the right vertical axis expresses Water in Industry. And the horizontal axis expresses the year.

Recycled Water and Water Recycle Rate increased rapidly in 1970s.



***The graph 3-1 Transition of Water Recycle Rate ("Industry census")***

---

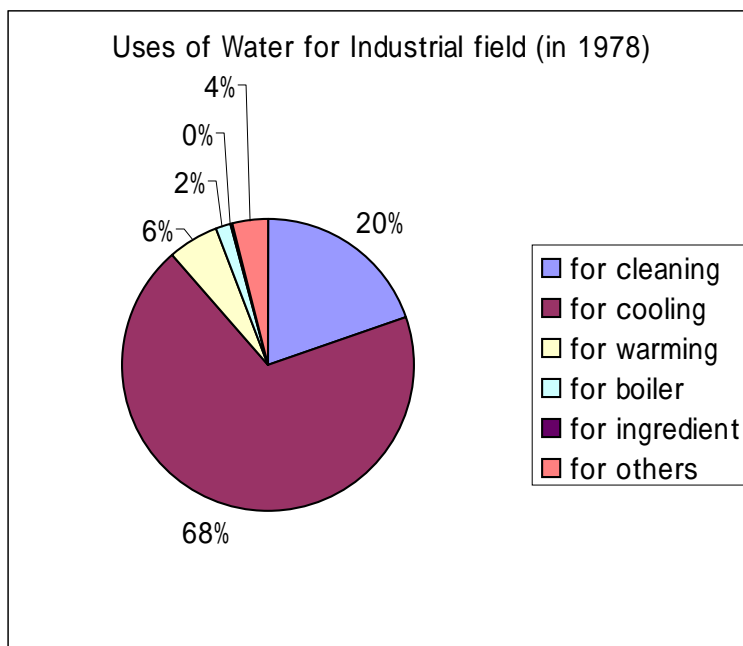
adopt the case when we have least rain fall /10years.

So, why Water Recycle increased rapidly in Industry in 1970s?

There is a technical reason.

Water used for Industry without Water used for ingredient, after used, became Waste Water. But, Water used for cooling and warming, is easier to recycle because it is little problem about quality. (That is to say, in many cases, water for cooling and warming don't touch products directly and isn't required so high quality.)

Please look at the graph -2. It shows uses of Water for Industry. There are much Water for cooling and warming.



***The graph 3-2 The uses of Water for Industrial field ("Industry census")***

In short, Water is easier to recycle if only factories introduced recycling facilities.

However, if factories do not introduce recycling facilities, Water Recycle Rate is not increasing.

Then, why so many factories introduced Recycling Facilities in 1970s?

## ***2. Why so many factories introduced Recycling Facilities in 1970s?***

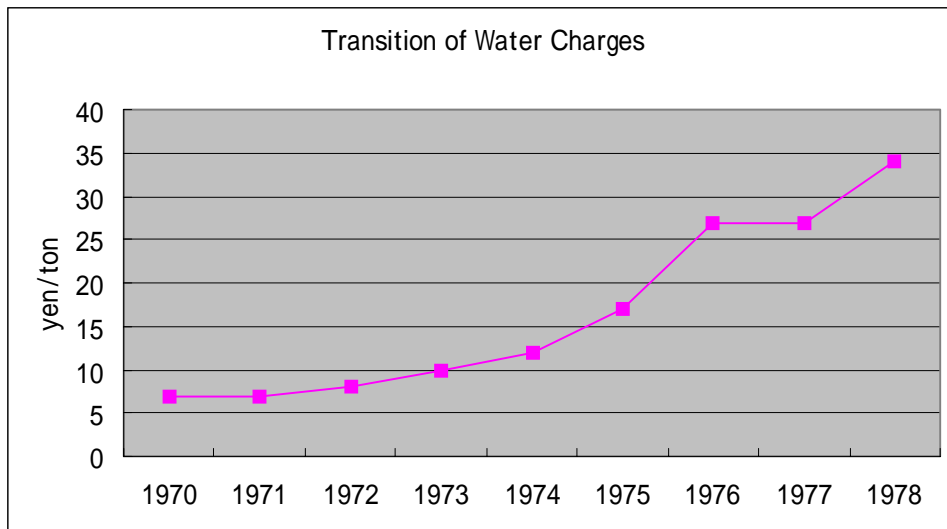
Why so many factories introduced Recycling Facilities in 1970s?

Increasing of Water Recycle is because of rising of prices of Water Charge in

Industrial Water Way<sup>3</sup>.

Please look at the graph -3. The graph shows the transition of Water Charge. It is Water Charge of newly installed water supply. In the latter half of 1970s, it increased rapidly. It is based on rising of Dam building costs and so on. The horizontal axis expresses the water charge per 1 ton of water.

However, Water Charge of newly installed is used to calculate compute subsidy. It shows a state at the time, but Water Charge of the existing water supply changes with areas.



***The graph 3-3 Transition of Water Charge (Installed newly)***

Although I said it increased rapidly, you may think that an at most 5 yen rise is a small problem. However in industry, each factory uses much water. For example, a certain large-scale iron-manufacture factory uses about 80thousands ton water per one day. So, it was a big problem for each factory.

Next, I will mention two case studies, and then I will explain the mechanism.

## ***2. Case Study 1~Water Charge & Water Recycle Rate in the steel industry in 1977 ~***

So, I will explain one case study.

The graph -4 shows Water Recycle Rate and Water Charge in the steel industry in 1977. The vertical axis expresses Water Recycle Rate in the main city and the horizontal

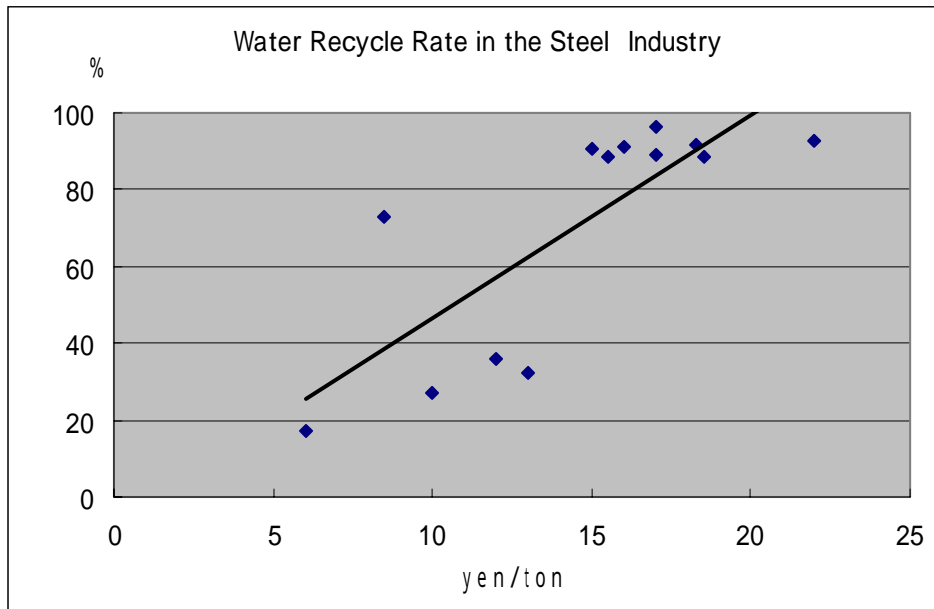
---

<sup>3</sup> Japan has two kinds of Water Way Supply Systems. Industrial Water Way is Water Supply only for Industry in Japan. It is not ordinary Water Supply (ex. for living, office, park etc.)  
In this report, I mention only Water Charge in Industrial Water Way.



axis expresses the Water Charge.

Why did I take samples in the steel industry? Because the steel industry is an industry that uses much water and is easier to carry out recycling because it uses much water for industry.



***The graph 3-4 Water Recycle Rate in the Steel Industry***

The area where the Water Recycle Rate is quite low also exists in the cheap area of a water charge.

It can be said that the Water Recycle Rate is high so that the Water Charge becomes high. The area where the Water Recycle Rate is quite low also exists in the cheap area of a water charge. It turns out that the Water Charge has affected Water Recycle certainly.

### ***3. Case Study 2~ The revision of Water Charge influenced Water Recycle Rate in Kawasaki~***

And I will explain another case study. It is a case study in Kawasaki.

Kawasaki is typical industrial city in Japan. In Kawasaki, the steel industries, the chemical industries, and so on, are located.

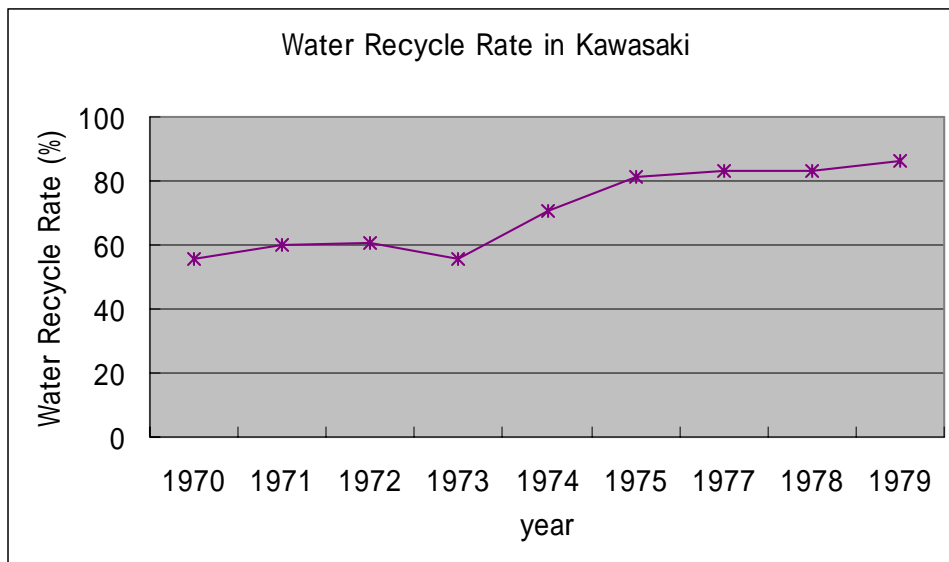
Please look at the graph 3-5. The graph shows the transition of the water charge of Kawasaki. The vertical axis expresses the rate of recycling and the horizontal axis expresses the year.

In the 1970s, there are two revision of water charge. After first revision in 1974, Water

Recycle Rate is rising greatly.

After second revision in 1978, Water Recycle Rate is not rising so much than before. But it is because Water Recycle has a technical limit.

The revisions are caused by the shortage of ground water and the shortage of the river water polluted by Waste Water.



***The graph 3-5 Water Recycle Rate in Kawasaki***

#### ***4. Comparison of the Cost when Recycling with the Cost when Not Recycling***

So, I will compare the cost when recycling with when not recycling.

The whole cost when recycling consists of Cost to introduce recycling facilities, Cost to manage Waste Water, Cost for Water Supply.

The whole cost when not recycling consists of Cost to manage Waste Water, Cost for Water Supply.

First, I will compare each cost when recycling with each cost when not recycling.

##### **(1) Cost to introduce recycling facilities**

The cost to introduce recycling facilities exists only when recycling.

##### **(2) Cost to manage Waste Water**

You may think “Why Waste Water relate to Water Recycle?”

Since 1970, factories must subject to the drainage regulations in Japan. Factories had to bear the costs to subject to the drainage regulations.

In fact, the Cost when recycling is cheaper than the Cost when not recycling. It based on technical reason.

### (3) Cost for Water Supply

Cost for Water Supply is multiplied Water quantity by Water Charge.

For example, if water for cooling is recycled, new water will require only 10% of the amount used. Therefore, the cost of water is 10% when not recycling water. Then, if the water charge went up, cost for water supply when not recycling will increase sharply.

So, let's compare the whole cost when recycling with the cost when not recycling.

$$(1) + (2) + (3) \text{ (When Recycled)} < (2) + (3) \text{ (When Not Recycled)}$$

If other costs are fixed, the whole cost when recycling can exceed the whole cost when not recycling according to the upsurge of a water charge.

When the whole cost when recycling can exceed the whole cost when not recycling, factories introduces recycling facilities.

In Japan, this actually happens, factories introduced recycling facilities, and recycling was performed in Industry. And, Water Recycle Rate increased.

### ***5. Conclusion of Chapter 3***

Thus, increasing of Water Charge promoted factories to introduce recycle facilities.

As a result, Water Recycle in Industry in 1970s. Rising of Water Charge worked as an economic incentive.

However, such rising of water charge in Japan was not performed as a policy as which Water Recycle is recommended. That is, although water charge goes up by rising of Dam development cost and so on. And it is accidental, it led to the increase in effective use of water rather than that worked disadvantageously for development of industry.

### ***Chapter 4 Conclusion***

Until now, we have discussed the water use of Japan focusing on industry.

Then what can be said from experiences in Japan, especially the experience in industrial field as a conclusion?

In industry, water recycling has been promoted unexpectedly. Water recycling was promoted as correspondence to a rise of the water price for industry. Although the policy which meant promotion of water recycling was not necessarily taken, as a result the economic incentive which promotes water recycling was produced. What we can say from this experience is that the amount of water used in industry tends to be influenced by economic incentives.

Then, take a look for other sections, i.e., water for living and water for agriculture. As mentioned above, the water use in living or agriculture has relation closely with our lives, and its stable supply at low price is desirable. That is, the control of the amount of water used in living or agriculture by the price fluctuation is not desirable. Especially about water for living, the rate of the expenditure on water to the income is set up low, and the price elasticity of demand is small. Moreover about agriculture, there is an element peculiar to Japan called the right of water use, and probably, the effective experience rule for a foreign country will not be drawn. Please consult the below-mentioned supplements about the details of water for living and water for agriculture.

Now, what we can advice to other countries after being based on experiences of Japan as mentioned above is "To control the amount of water used in industry, it is effective to utilize economic incentives." From unexpected result that water recycling has been promoted by economic incentives, it can be conversely said that utilization of economic incentives is effective in case of promotion of water recycling.

Industry is an element indispensable for a state. Moreover, considering the climate change in the future caused by global warming, not only for the area with insufficient water at present but also for the area with sufficient water at present, it is indisputable that efficient use of water becomes more important.

It is thought that the conclusion drawn from the experience in Japan in industrial field, "To control the amount of water used in industry, it is effective to utilize economic incentives" will be helpful to the world. In case each country promotes efficient use of water, probably, this conclusion drawn from experiences of Japan can play a certain role. And we are happy if the water crisis in the future is eased as the result.

Now, that's all for our conclusion.

## Chapter 5 Annex

Then, as supplements, we will describe the prospect of the situation of water use in Japan in the future, and the possibility of new policy about water resources.

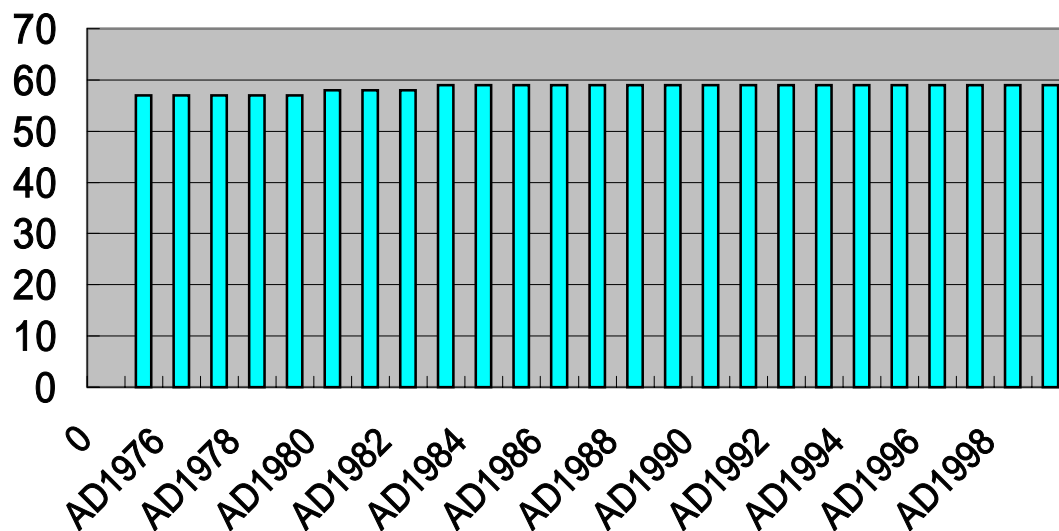
First, we will describe about agriculture.

In recent years, arable-land area is decreasing in Japan. Therefore, as long as there is no drastic change in food policy, it is hard to consider that the amount of water used for agriculture increases greatly in the future.

First of all, since it is old, governing the paddy field has been considered as the symbol of power in Japan. That is, the paddy field has been treated well politically. For the reason, historically, the right of water use has been allocated preferentially. This right of water use is still set up, and has caused rigid use of water in agriculture. Concretely speaking, the amount of water used for agriculture does not decrease, even if arable-land area decreases as mentioned above. Please look at the following graphs.

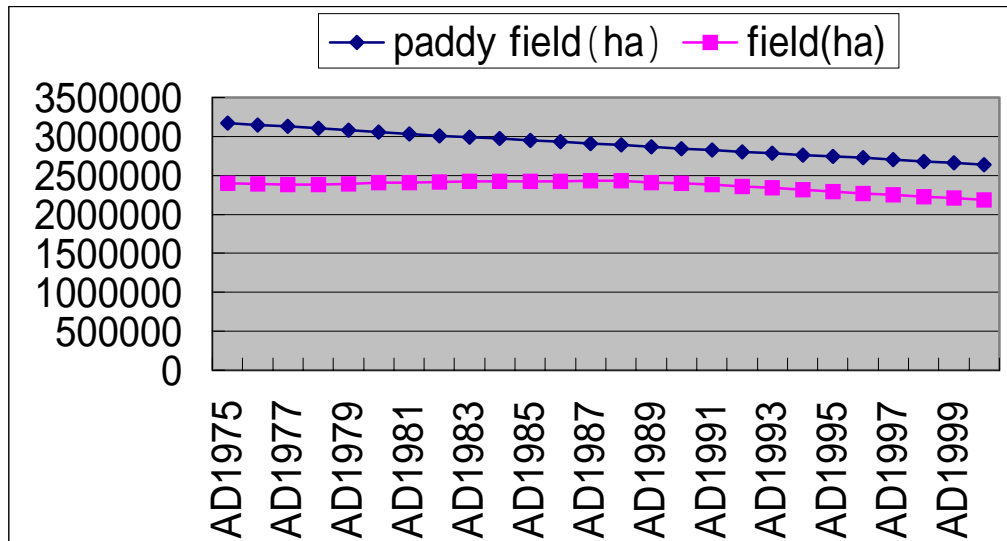
Graph5-1 change of the amount of water used in agriculture in Japan

(billion cubic meter) (2000/Ministry of Land, Infrastructure and Transport)



Graph 5-2 change of the area of paddy field and field

(2000/Ministry of Agriculture, Forestry and Fisheries)



Graph5-1 shows the change of the amount of water used for agriculture in Japan. Graph5-2 shows the change of the area of fields. These two graph show that the amount of water used for agriculture is not decreasing in spite of reduction of the arable-land area of fields. This shows that the water use in agriculture is rigid in Japan because of the right of water use that has been set up historically.

As mentioned above, although it is hard to consider that the amount of water used for agriculture increases sharply in the future, conversely, it is important to use water more efficiently.

As for Water Demand for industry in the future, the Water Demand will not increase more than now. It has two reasons. One is the Change of the Industrial Structure. Industries need more waters (ex. the Steel Industry, the Paper Industry) produced less than before.

Instead of that, Industries need less water (ex. Machine Industry) produced more than before. Another one is the increase of Water Recycle Rate. Water Recycle Rate is very high, but it is still increasing. So, the Water Demand for industry will not increase more than now.

#### Water used for living in future

As mentioned in chapter 4, it is hard to regulate water for living at price. Therefore , the amount of water used for living has been not controlled by price and increased in connection with the increase in population, the improvement of living standard and change of life style.

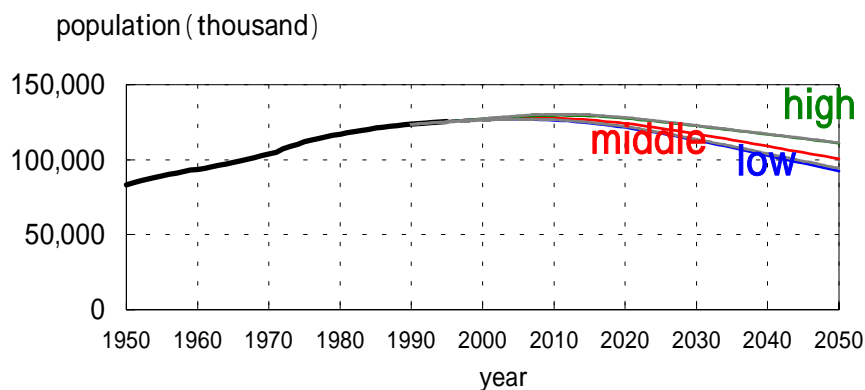
In this part, we consider about the trend of water demand for living in future. And as we described in chapter 2, we think the factor which increase amount of water used for living is 1,increasing of population, 2,increasing of water to use per one person. And about second factor, we think it caused by 2-A,increasing of bathtub possession, 2-B, increasing of flushed toilet possession, 2-C,increasing of the number of households.

Here, first we consider about the factors which increase water use, next we describe the factor which decrease amount of the water use.

The factors which increase the amount of the water use.

### 1 population

According to the middle estimate of National laboratory social security and population , peak of population in Japan is 127,78 million in 2007.and from that time, it will change to reduction.



5- ) the estimate of population ( National laboratory social security and population )

### 2-A the rate of bathtub possession

it will not increase much more than now. Because there is less room to increase. As seen in the figure in chapter2, the rate exceed 95% now.

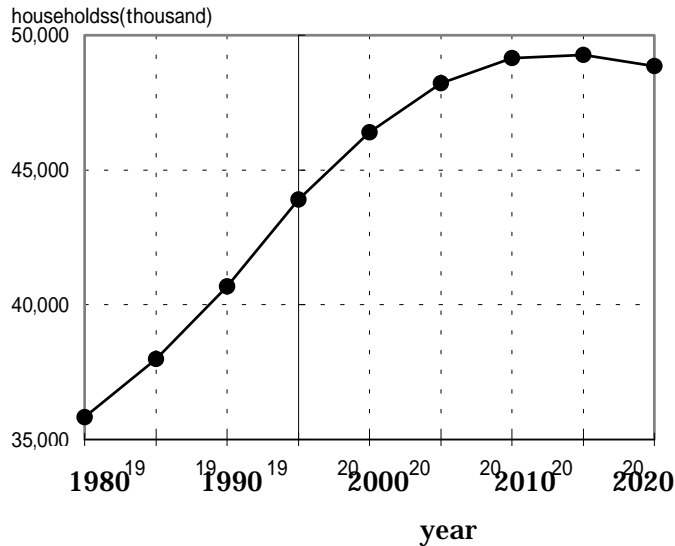
### 2-B the rate of flushed toilet possession

it reach 83%, and there is room to increase. But 97.5% of new houses built after 1996 own flushed toilet. So we think the increasing will stop in about 45 years. Because in Japan, it is known that the life of house is 50 years.

### 2-C number of households

according to National laboratory social security and population, the peak of number of

households will 49,29 million in 2014, and it will change to reduction after the time later than the population for 7years.



5- ) the estimate of number of households  
( National laboratory social security and population )

So we think increase of water demand of living will stop in 45 years at latest. Because all factors will not acted in the time.

Next, we want to also mention the factor to reduce water demand.

As we said number of times, price does not work to reduce the water demand for living. However , the saved water type household-electric-appliances act the factor to reduce water demand.

Especially, we use less water than past at toilet and washing machine. We use 11~20L of water at toilet per one time. If we use the saved type, we can save 2~7L of water.

And the amount of the water use per 1kg of wash has been decreasing to about 1/3 from 1973. Thus people can reduce water used for living by using appliances that are more efficiently without changing life style. So, we think household electric appliances become the save type more, the amount of the water use per one person will also become less.

As the result, although the amount of water used for living may increase several year

---



from now, we think it decreases after that. Because the factors which increase the amount of water will not act and the factor which decrease the amount of water act more.

## **5.2 What Japan Can Do for the World**

As stated above, it is true that water demand does not exceed water supply now in Japan, according to factors such as development of the technologies from the past. Based on these experiences of Japan, the present economical position, and the present condition in the world, we examine what Japan can do for the world from “Technology Transfer” in a short viewpoint, and “Water Trade” in a long viewpoint.

### **5.2.1 Technology-Transfer**

Preceding chapter, Japan has the things of highest Mine also in the world, such as water recycling for industry, and for a life, and the saved type household electric appliances of water, about the technology which uses water effectively. These technologies should be harnessed immediately in the few country of the world, especially the countries which don't have enough water resources. In this chapter, we will examine what Japan can do for the world, especially “Water Recycling for Industry” which Japan has cultivated in past and “Freshening of Sea Water” which has been challenged newly.

### **5.2.2 The Technology of “Water Recycling” for Industry**

It is about the percentage of “water recycling” for industry.

Although rapid industrialization is progressing in developing countries in recent years, it is the present condition that the percentage of water recycling for industry has not caught up with this development.

Water recycling for industry in a factory condenses the detrimental substance in waste water, it also has the secondary effect of making purification processing to carry out.

The Chinese percentage of water recycling for industry is mentioned as an example. In China, a percentage of water recycling exceeded 30% in 1991, and it should reach to about 60% in the end of the 1990s. Although it was able to say that this growth rate was high, I would like you to see Chart V -1. If this graph is seen, in Japan, the percentage of water recycling exceeded 30% in 1964, and it has reached to 62% in 1973. That is, it is

the fact, it did not take no less than 10 years for a percentage of water recycling becoming 60% from 30% also in China or Japan. However, in Japan, although a percentage of water recycling makes little increase and is attained to 80% from 60% after that, more than 20 years have passed. This is because that 60% or more is hard for water recycling recovery for industry.

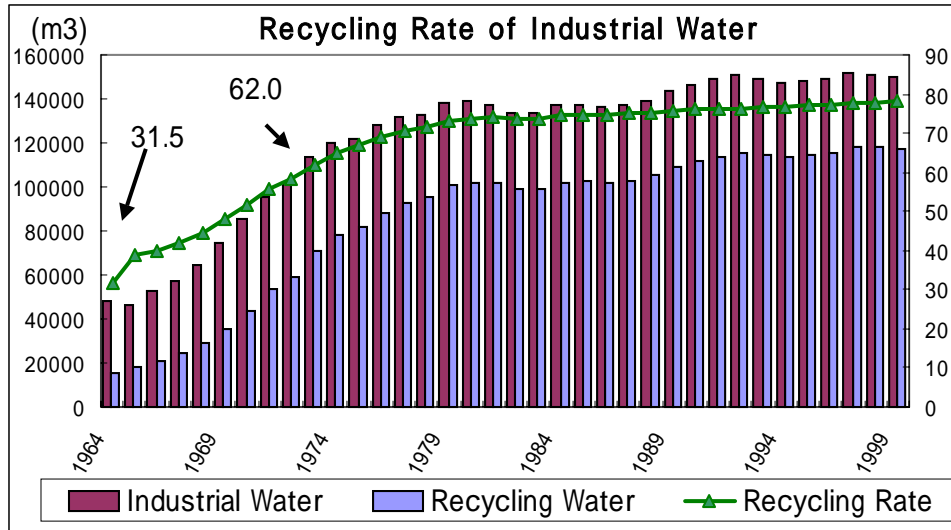


Chart - 1 Recycling Rate in Industrial Water

resource: Industry census

However, because it is possible that the developing countries introduce the technology of the water recycling which advanced nations, such as Japan, have cultivated. If even technical introduction is performed, it will be considered that high rate of water recycling is realizable immediately in these areas.

In Taiwan, because a percentage of water recycling was about 32% at the time of 1995, technical introduction is desired also.

Although this technology may be a large sum, just when a large sum in this way, probably, ODA (official development assistance) should be carried out.

### 5.2.3 The Technology of "Freshening of Sea Water"

Chart 2 is "Transition of Freshened Sea Water". From this chart, we can read that the percentage of contributions by Japanese corporations is the high value always of 30% or more in recent years. From this, the importance of Japan in the freshening enterprise in the world is clearer.

However, “Freshening of Sea Water” is holding some problems. Below, we will mention present problems in “Freshening of Sea Water”, and we will consider what Japan can do to them.

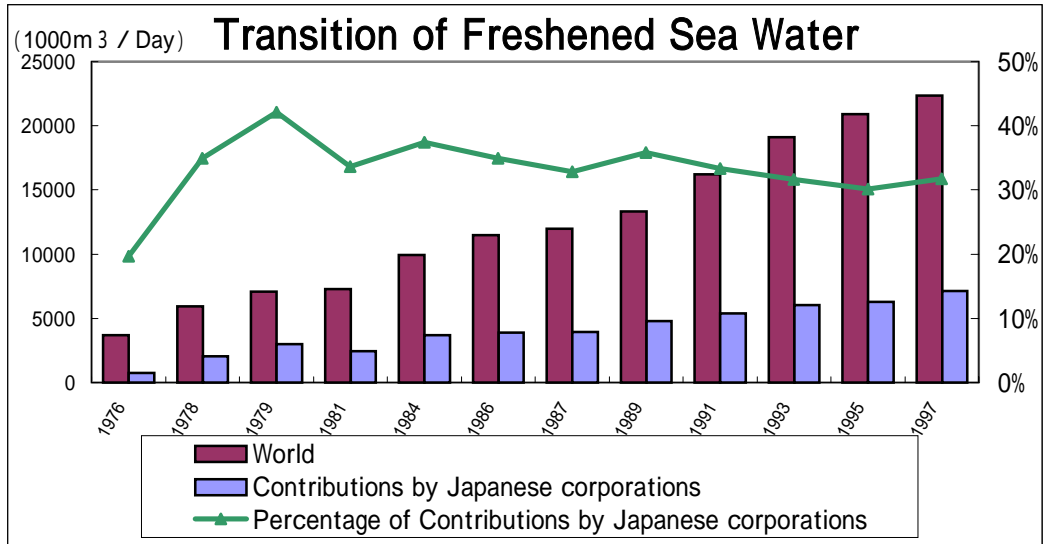


Chart - 2 Transition of Freshened Sea Water

resource : Water-Service Yearbook(2001)

### 5.2.3.1 [Problem 1] Size of Consumption Energy

The first problem is about the size of consumption energy.

First, chart - 3 “Freshening Plant of Each Area” is shown. It can read from this that many freshening plants are introduced in Middle East area or the U.S.. Many plants are especially introduced in the Middle East, and the rate is more than the half in the whole world.

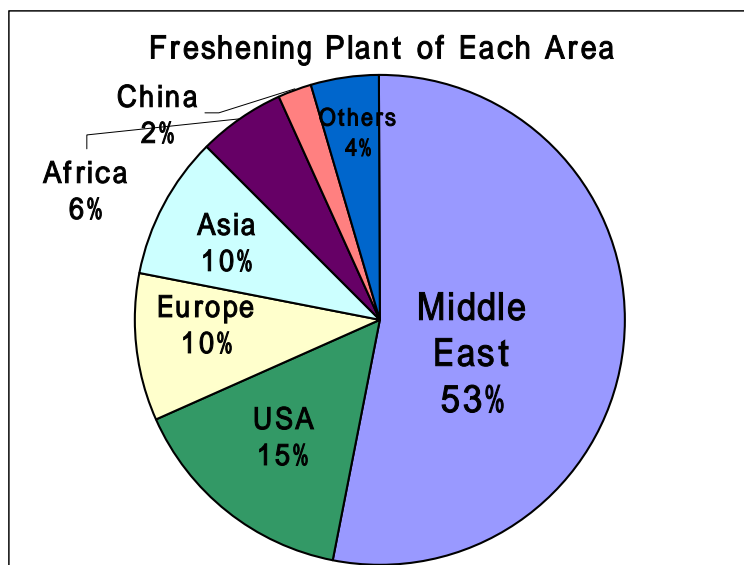


Chart - 3 Freshening Plant of Each Area

resource : MITI "Tomorrow's Water Resource"

Although we mentioned above that many plants were installed in the Middle East area or the U.S., it is the Middle East area that Japan is introducing preponderantly. The reason was shown below, there are three.

- ( 1 ) There are many countries troubled by water in Middle East.
- ( 2 ) There are many crude-oil production countries and energy exists abundantly.
- ( 3 ) By crude-oil export etc., finances are moistened comparatively.

About the energy of (2), chart - 4 is "The Energy Consumption in Each System", and chart - 5 is "Transition of Freshening Plant (Each Method)".

Method	Energy Consumption ( kWh / )
Evaporating method	about 25
Reverse Permeating method	about 7
Electricity Permeating method	18 ~ 19
L N G Using method	2.4

Chart - 4 Energy Consumption in Each System

resource : MITI "Tomorrow's Water Resource"

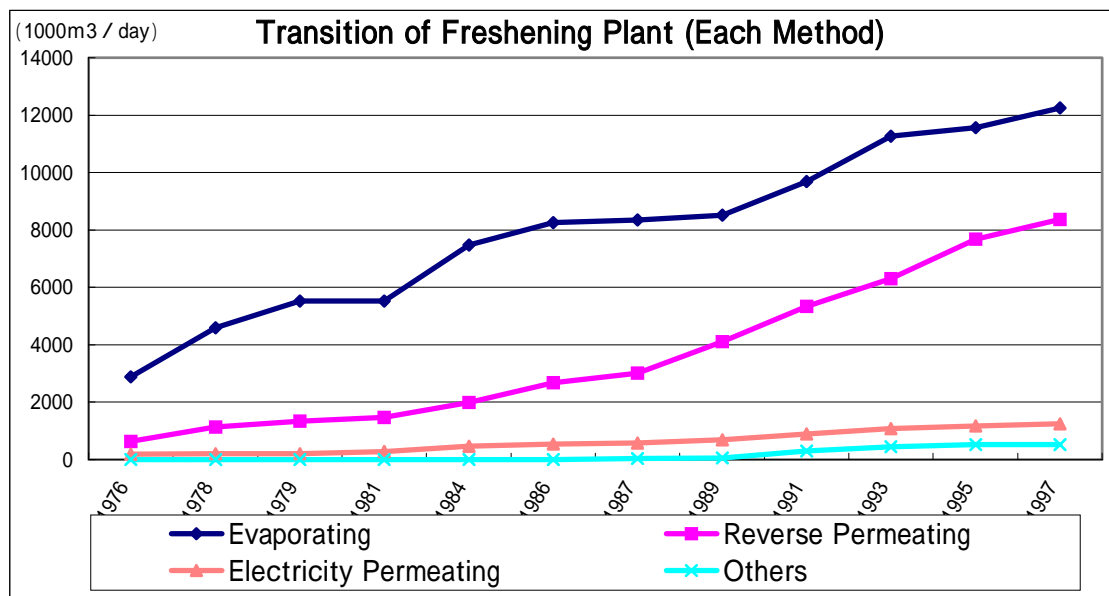


Chart - 5 Transition of Freshening Plant (Each Method)

resource : MITI "Tomorrow's Water Resource"  
Water-Service Yearbook (2001)

From chart - 4, the evaporating method and the electric permeating method need large energy consumption, and the reverse permeating method and LNG using method need small energy consumption. As for this, the Middle East area has many production countries of crude oil, and since the energy which heats sea water exists in large quantities, it is because evaporating method is adopted.

Since consuming energy in large quantities is connected also with warming gas discharge which causes the Global Warming, energy efficiency is improved or the further spread of low energy plants, such as the reverse permeating method, etc. is desired.

### 5.2.3.2 [Problem 2] Construction Cost of Freshening Plant and Price of Freshened Water

Next, it is about the construction cost of freshening plant and price of freshened water.

Chart - 6 is "Processing Capability and Construction Cost of Freshening Plant", and chart - 7 is "Operation Cost of Freshening Plant (Reverse Permeating method)".

Area	Processing Capability ( / day )	Construction Cost
------	---------------------------------	-------------------

Japan( Fukuoka )	50,000	55 billion yen
Japan( Okinawa )	40,000	34.7 billion yen
Taiwan	130,000	50 billion yen
Israel	140,000	150 million US\$ ( 1\$=120yen · about 18.2 billion yen )

Chart - 6 Processing Capability and Construction Cost of Freshening Plant

resource : Polyethylene Pipe Study-Group "E-Water Issue"

Western-Japan Newspaper August 22, 1998 morning

Prefecture Office of Okinawa HP "Outline of Freshening Plant Construction "

Quantity of Freshening ( / day)	Unit Price at 1 (yen)
30 or less	108.8
110	56.56
220	52.83
660	48.26
1000	46.85
3000	46.85

Chart - 7 Operation Cost of Freshening Plant (Reverse Permeating method)

resource : Water Processing Ace Company HP

"Operation Cost Table of Newest Model"

From these two charts, we can know that the construction cost of freshening plant is very large, and the operation cost is also large, too. For example, the fresh water is 200 yen per 1 at the freshening plant in Japan. In Japanese waterworks, the water is about 100 yen, it can judge how the price of freshened water is expensive.

The countries troubled by water are economically poor in many cases. Therefore, they cannot buy these freshened water except the countries such as oil producing countries.

Above is a problem in construction cost of freshening plant and price of fresh water.

#### 5.2.4 What Japan Should Do To These Problems?

Then, we will examine that what Japan should perform from now on about the problems, "size of consumption energy" and "construction cost of freshening plant and price of freshened water".

First, it is about consumption energy, we think that solution of this problem is the civilian-enterprise person's active entry.

Although enterprises which is performing freshening of sea water in present Japan

are only Toray Industries, Toyobo and etc., probably competitive power will work, the technical development for every entrepreneur will progress, and can also achieve low energy consumption, if many entrepreneurs gather further.

Although many entrepreneurs' active entries can be also one of the solutions of the problem "construction cost of freshening plant and price of freshened water", we considered that there is a limit.

There is no guarantee lowered to the degree which can be purchased to people of a poor country though the price of freshened water can be lowered, first of all, an entrepreneur does not make an investment countries where economy is not moistened.

Energy efficiency will become good if an entrepreneur is left. However, it will concentrate on the country where economy is moistened. That is, it may become "water is gathered only in the place where much money exists".

Then ODA (official development assistance) is considered. We think that not only entrepreneur but also the country (Japan) should carry out further assistance to a poor country. Because ODA does not ask for profits, it is performed just in a poor country. Although Japan is performing dispatch of the engineer of freshening and cultivation of an engineer in the countries (Saudi Arabia, Arabia, Abu Dhabi, Egypt, etc.) where the request is brought from 1970s, we think that these should be made still more active. Then probably, the freshening plant can be introduced also in the poor country.

As mentioned above, technology of freshening sea water can be introduced also into the poor area where water is just now lacking, with promoting energy saving, if ODA and entrepreneurs' active entries is performed. This is Japan which has supplied 30% of the freshening plants, therefore able to do.

### **5.3 Water Trade**

In the area with little water resources, "Water Trade" is attracting attention in recent years. "Water Trade" is trade which exports water to the country with little water resources from the country with much water resources. It has just started in 2001, and this trade is only being carried out between Turkey and Israel, Turkey and Cyprus now. The amount of transactions is about 20,000t per one voyage, and this water is mainly used for drinking. Furthermore Turkey is planning the water export to Libya, Jordan, or Saudi Arabia. If early, trade is expected to be started less than in several.

Because "Water Trade" not only calls stabilization of the water resources of an area with little water, but an export country has the international influence like a crude-oil export country, concerns are collected.

Although we mentioned that water trade was performed only between Turkey and Israel, Turkey and Cyprus. There is a company which is making an investment to water trade in Japan. This company is Nihon Yusen which is one of the greatest shipping trade company in Japan. Nihon Yusen acquired 34% of the stocks of the water transportation corporate named Nordic Water Supply Company of Norway in February 2000, and acquired the right of management of this company.



Chart - 8

The Big Bag Loading Drinking Water, and Tugboat.

resource: Nihon Yusen HP "Capital-Participation to Water Transportation Company"

Nordic Water Supply Company has skills of water trade by using a big bag. It is possible to load drink water (10,000t or 20,000t). By tugging this bag by tugboat, it is cheaper than by using tanker. Nihon Yusen is going to contribute to relief of water shortage by using this technology.

If water trade becomes active in the world, probably, the competitive power will bear. And, it will enable the countries with little water resources to purchase water more



cheaply

Moreover, if more companies in Japan enter into the water trade market like Nihon Yusen, Japanese companies can get skills of water export.

And, Japan can become "Water Producing Country" by using these skills. From preceding chapter, we can say that water supply exceeds water demand and water is left over in Japan. It is significant not only for the world but also for Japan, to export this water to a foreign country. If value of water resources will increase from present in the future, a possibility that export water direct from Japan is performed will come out.

#### **5.4 The Future of Japan**

It entered in the 21st century, "Water Trade" started, moreover technologies, like "Water Recycling" and "Freshening of Sea Water", will develop in the world. In such a situation, Japan should entry and assistance to them, as a country which conquered the problem about water resources. Furthermore, because the problem of water resources will develop into the "Water Business" which can expect sufficient profit after this, this may serve as profits also for Japan.

The Vice-President of the World Bank said.

"Although the 20th century was the century of Oil, the 21st century will be the century of Water."

#### **Reference**

- "Water Resource Problem in contemporary Japan" Kenichiro Moritaki 1982 Shobunsha
- "Water Service in Japan" Akihiro Terao Toyo Keizai Shinpo-Sha 1981
- "Industry census" Ministry of International Trade and Industry each fiscal year
- "Water - the interdisciplinary approach" Japan Society for the Promotion of Science Maruzen 1983
- "Land subsidence and Industrial Water Law" Nobuo Kurata Maruzen 1971
- "Water for industrial use and its water quality managing" Kankichi Toyoda 1972 Shokodo
- "Water for industrial use resources" Water supply science research institute Chijin Shokan 1962
- "Water for industrial use supply in Japan" Noboru Hida Taga publication 1982
- "Industry and Pollution" (each fiscal year) Ministry of International Trade and Industry
- "Environmental conspectus 2001" Ministry of Economy, Trade and Industry, the Japan Society for the Promotion of Science
- "Exhaustion and Distribution of Water Resources" Naraomi Imamura, Tokyo Publication 1996
- "Warning to the countries of importation of food" Kenji Horiguchi, Tokyo Publication 1993

Ministry of Agriculture, Forestry and Fisheries (<http://www.maff.go.jp/>)

Ministry of Land, Infrastructure and Transport (<http://www.mlit.go.jp/>)

World Water Vision

Video ; NHK 'The Century of Water Resource Will Come'