Economic Instruments for Basin-wide Efficient Pollution Load Reduction - Comparison between Effluent Charges And Water Quality Trading -

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Abstract: Sewerage Law was amended in 2005 and a modified approach was established by introducing the concept of transferable LRA (Load Reduction Assignment) for nitrogen and phosphorus in the basins of enclosed water bodies. The modified approach is supposed to play a role equivalent to water quality trading which has been adopted successfully in the U.S.. Meanwhile the effluent charge system combined with subsidy is widely employed with great success in European countries such as Germany. Through simplified mathematical models, the comparative features on equity and reflection of local conditions as well as equivalency between the two economic instruments are theoretically discussed. The mathematics for both the effluent charges and water quality trading suggests an equivalent cost-effectiveness in meeting a predetermined target. Water quality trading could be easily designed on the basis of the total sum of permits that is the predetermined target of the policy, while effluent charge system cannot be designed directly from the target. In contrast, effluent charge system is assumed to be superior to water quality trading in terms of equity and the reflection of local conditions.

Keywords: effluent charge, water quality trading, transferable permit, load reduction assignment, amendment of Sewerage Law

1. Introduction

Economic, engineering and political studies as well as administrative experiences have revealed that traditional "command-and-control" measures are not enough to address the externality-related issues such as environmental management strategies. Economic instruments are considered to be cost-effective alternatives, which should be applied solely or together with command-and-control method[1),2)]. As for the economic instruments for water pollution control, typical examples are effluent charge system and water quality trading. The former is very popular in European countries, among which Germany has made the greatest success of pollution prevention[3)]. The latter has been applied to quite a few watersheds in the United States, where Environmental Protection Agency (EPA) issued Water Quality Trading Policy in 2003 to facilitate the attainment of Total Maximum Daily Load through water quality trading[4)]. Comparative studies were conducted focusing on these two methods from the viewpoint of applicability to sewerage works in Japan. Furthermore there were energetic arguments for and against employing new economic incentives and scientific discussions about the design of the legislation.

2. Difficulties Relating to Advanced Treatment

The water quality has been improved gradually so far in rivers. But most of the enclosed water bodies such as bays and lakes are not getting cleaner in spite of the progress in the population served with sewage treatment (See Figure 1). It is no wonder that those enclosed stagnant water bodies, which are severely polluted by eutrophication, require the reduction in nitrogen or phosphorus inflow through the promotion of advanced treatment of sewerage systems in those basins. In particular, advanced treatments in Tokyo Bay and Osaka Bay basins are considered to be most effective because almost 90% of population is covered by sewerage and more than half of nitrogen and phosphorus inflows into those water areas through effluent from public WWTP(wastewater treatment plant)s. Therefore, it is no exaggeration to say that the averaged water qualities in Tokyo Bay and Osaka Bay are fundamentally controlled by the water quality of the effluent from public WWTPs. However the rate of population covered with advanced treatment is very low, 3.6% for Tokyo Bay and 14.1% for Osaka Bay as of the end of fiscal 2003.

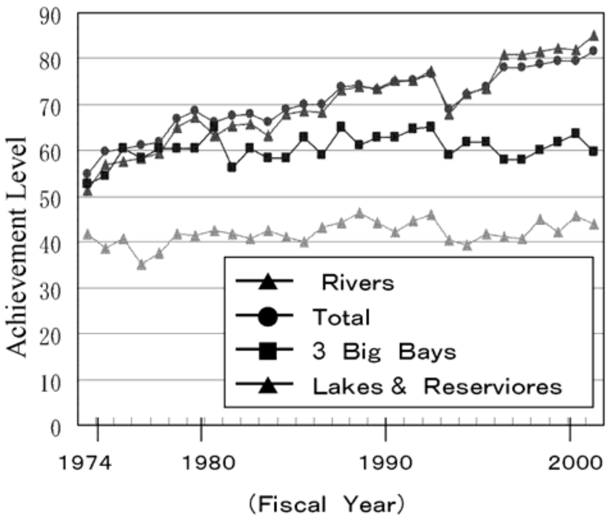

Figure 1: Achievement of Environmental Water Quality Standard

Notes :
1.BOD used for rivers, and COD used for lakes/reservoirs, and sea/coastal areas.
2.Achievement level (%)=(no. of water bodies achieving / number of designated water bodies) × 100
Source : Ministry of Environment

The requirements of advanced treatment i.e. effluent water quality that each WWTP is to meet are usually determined by CBPSS (Comprehensive Basin-wide Plan of Sewerage Systems). CBPSS was legislated in the Sewerage Law as early as 1970. Every prefecture is by law to formulate CBPSSs for ordinance-required water bodies to drive local entities concerned to advance their sewerage construction/improvement projects toward the attainment of EWQS (Environmental Water Quality Standard) in the targeted water bodies (See Figure 2). Although Sewerage construction/improvement programs shall be made and implemented "in accordance with" the relevant CBPSS, CBPSS could not function as strict command-and-control measures and it is often very difficult to guide local entities toward advanced treatment just as is required by CBPSS for the following reasons;

(1) Sewerage Law postulates that CBPSS should be formulated taking cost-effectiveness into account. Basin-wide cost-effectiveness is theoretically guaranteed on the condition of the equalization of marginal reduction costs across all the WWTPs in the basin. However prefectures formulating CBPSS cannot determine the marginal reduction costs beforehand in reality.
(2) The expression "in accordance with" does not necessarily imply "coinciding with" juridically. Therefore it is not perceived as illegal for local entities to postpone, for some reasons, the initiation of advanced treatment which CBPSS requires. In other words, command-and-control method cannot be easily applied on the basis of CBPSS.
(3) Generally speaking, local entities tend to be unwilling to forward the program of advanced treatment in pursuit of downstream benefit alone. Meanwhile, there is often no sufficient reasonable persuasiveness other than downstream benefit to make local entities carry out programmed advanced treatment.

Taking heavily polluted lakes and bays into consideration, some kind of modified approach was obviously needed to promote the advanced treatment in Japan.

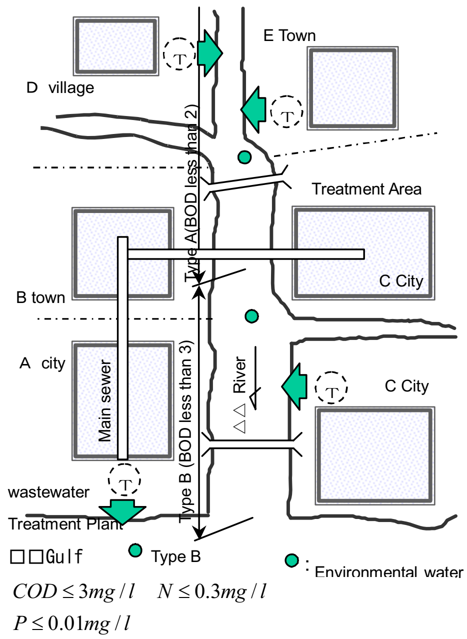

Figure 2 : Schematic Diagram of CBPSS

3. Modified Approach

Sewerage Law was amended in 2005 and a modified approach was established by introducing the concept of LRA (Load Reduction Assignment) for nitrogen and phosphorus in the basin of enclosed water bodies. Transferable LRA is somewhat similar to transferable permit in the water quality trading employed in the U.S.. While water quality trading is founded upon NPDES (National Pollution Discharge Elimination System), LRA is a concept in CBPSS and therefore only applied to the advanced treatment of WWTPs.

The outline of the amendment of Sewerage Law is as follows;

A. Determination of the Baseline LRA

Prefecture shall determine the baseline LRA for nitrogen or phosphorus contained in the effluent of relevant WWTPs in the CBPSS which targets on enclosed water bodies where EWQS of nitrogen or phosphorus is set.

B. Cooperation for Advanced Treatment between Local Entities

B-1 Proposal of Substitution

Local entity can submit to the prefecture a proposal that it will substitutively fulfill the LRA assigned to the other entity's WWTP, after reaching the agreement with the local entity to be substituted for on this issue.

B-2 Registration in CBPSS

The prefecture that has received the proposal of substitution can register the information of the substitution including the estimated cost and its sharing in the CBPSS.

B-3 Payment for Substitution

The local entity that substitutively fulfills the LRA assigned for the other entity's WWTP can, as the legal effect of the registration in CBPSS, make the entity to be substituted for pay the cost for the substitution including the cost of construction, improvement, rehabilitation, repair, maintenance and control.

B-4 Subsidy Rate

As to the construction or improvement of the facility which is carried out for the purpose of the substitution, the subsidy rate for the WWTP whose LRA is substitutively fulfilled is applied. In the calculation of subsidy, the cost specified for the other WWTP is basically derived from the ratio of LRA for the other WWTP to all the LRA to be fulfilled by the facility.

Legally there is no concept of the permit for discharging pollutant, much less the concept of transferable permit in Japan. After juristic studies, the concepts of LRA and substitution for another WWTP's duty on LRA were introduced to substantially establish the transferable permit for discharging pollutant, i.e. transferable LRA on the basis of CBPSS. In other words, transferable LRA is supposed to play a role equivalent to transferable permit in water quality trading. Modified approach with transferable LRA is expected to substantially abate aforementioned difficulties to guide local entities toward advanced treatment, because local entities, which can take the choice of substituting for the other local entities or being substituted for by the other local entities on LRA, will be able to conform to the CBPSS more easily as a whole.

In course of the studies on economic instruments for advanced treatment, it was pointed out that effluent charge system has quite a bit advantage over water quality trading. However, the modified approach seems to have been favoured by policy makers mainly because of its plain structure that could be designed easily on the basis of predetermined target as well as of the general public resistance to charging/taxation.

4. Theoretical Comparison

This chapter deals with some theoretical considerations in order to make a comparison between effluent charges and water quality trading. Herein, let effluent charge system be combined with subsidy where the collected charges are distributed to WWTPs for their advanced treatment and “effluent charge system” or “effluent charges” is referred to as “effluent charge system combined with subsidy” in this paper. In water quality trading, transferable permit of each WWTP can be sold to or be bought by the other WWTPs as marketable goods. The modified approach shown in the preceding chapter is similar to water quality trading system, which is referred to also as “transferable permit system”. Figure 3 is the schematic diagram of theses two types of economic instruments. Take notice of the relation that the permit seller is correspondent to WWTP which substitutes for the other WWTP in terms of LRA and that the permit buyer is correspondent to WWTP that are substituted for by the other WWTP. Baseline load is the initial permit allocated between WWTPs. In water quality trading system, only the portion above baseline load is transferable.

Let the targeted water be completely mixed and receive m constituents of pollutant discharged from n WWTPs, each of which has its own cost and marginal cost functions related to any value of discharged pollution load of m constituents. Both effluent charge system and water quality trading are supposed to be separately applied to the WWTPs in the watershed with the policy to reduce the total sum of pollution loads to predetermined target values. Definitions of the variable symbols are listed in Appendix Ⅰ.

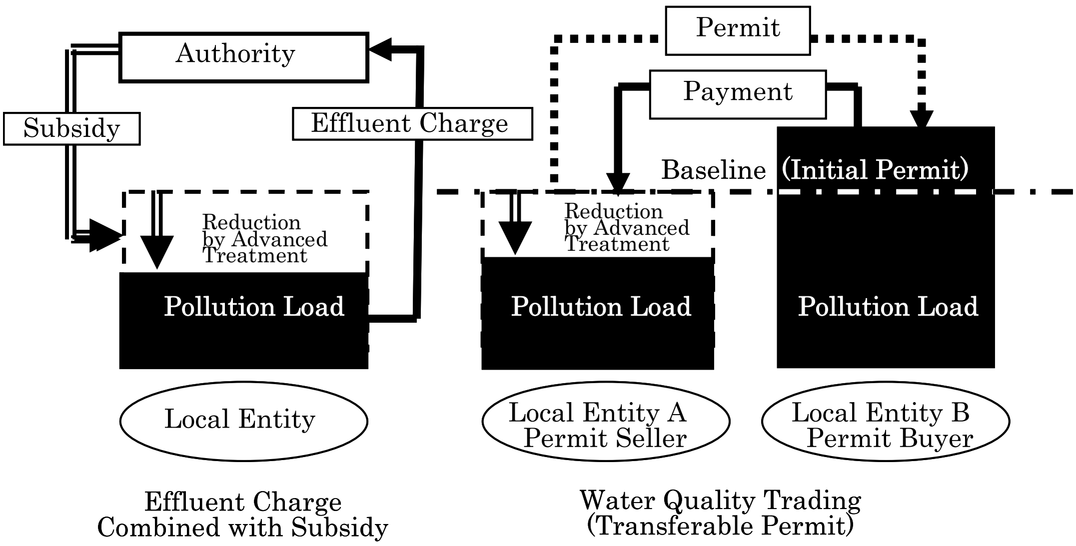

Figure 3 : Schematic Diagram of The Two Types of Economic Instruments

4-1 Equivalency between The Two Types of Economic Instruments

<u>In water quality trading</u>, net cost for each WWTP is expressed as follows:

$$y_i = c_i + \sum_{k=1}^{m} \alpha_k (x_{i,k} - L_{i,k}) \qquad (1)$$

where (net cost) $\equiv$ (cost for advanced treatment) + (expenditure for acquiring permit) − (revenue by selling permit).

As each WWTP tries to minimize the net cost for given α_k,

$$\frac{\partial y_i}{\partial x_{i,k}} = \frac{\partial c_i}{\partial x_{i,k}} + \alpha_k = 0 \qquad (2)$$

This is the condition of market equilibrium. On this condition, we have:

$$\frac{\partial c_i}{\partial x_{i,k}} = \frac{\partial c_j}{\partial x_{j,k}} = -\alpha_k \quad \text{for} \quad i \neq j \tag{3}$$

That is, marginal cost for advanced treatment of the constituent k is equalized to α_k for every WWTP. Eq. (2) and eq. (3) are necessary conditions and so, if the net cost is minimized for any WWTP i, then $x_{i,k}$ and α_k should satisfy eq. (2) and eq. (3). In pursuit of simplification, let us skip the perplexing discussions about the existence of appropriate solutions hereafter.

The total sum of the net cost Y is expressed as:

$$Y = \sum_{i=1}^{n} c_i + \sum_{i=1}^{n}\sum_{k=1}^{m} \alpha_k (x_{i,k} - L_{i,k}) \tag{4}$$

Taking eq. (3) into account,

$$\frac{\partial Y}{\partial x_{i,k}} = \frac{\partial c_i}{\partial x_{i,k}} + \alpha_k = -\alpha_k + \alpha_k = 0 \tag{5}$$

which means that Y is minimized.

If the total amount of sold permit is equal to the total amount of bought permit for every pollutant, then

$$\sum_{i=1}^{n} (x_{i,k} - L_{i,k}) = 0 \quad \text{for any } k \tag{6}$$

Consequently,

$$Y = \sum_{i=1}^{n} c_i + \sum_{i=1}^{n}\sum_{k=1}^{m} \alpha_k (x_{i,k} - L_{i,k}) = \sum_{i=1}^{n} c_i \tag{7}$$

This means that total cost of advanced treatment is minimized as well as total sum of net cost.

Since the condition (6) is not always satisfied and $\sum_{i=1}^{n} (x_{i,k} - L_{i,k}) \prec 0$ for any WWTP in general,

$$Y \prec \sum_{i=1}^{n} c_i \tag{8}$$

This means that some permits are usually left unsold and that some kind of system of buying the surplus permits might be necessary to bridge the gap between demand and supply of permits.

<u>In effluent charge system</u>, net cost for each WWTP is expressed as follows:

$$y_i = (1-g)c_i + \sum_{k=1}^{m} \beta_k x_{i,k} \tag{9}$$

where (net cost) $\equiv$ (cost for advanced treatment) $-$(subsidy for advanced treatment)$+$(effluent charge).

As each WWTP tries to minimize the net cost for given g and β_k,

$$\frac{\partial y_i}{\partial x_{i,k}} = (1-g)\frac{\partial c_i}{\partial x_{i,k}} + \beta_k = 0 \tag{10}$$

$$\therefore \quad \frac{\partial c_i}{\partial x_{i,k}} = \frac{\partial c_j}{\partial x_{j,k}} = -\frac{\beta_k}{1-g} \quad \text{for} \quad i \neq j \tag{11}$$

This means that marginal cost for advanced treatment of the pollutant k is equalized to $\frac{\beta_k}{1-g}$ for every WWTP.

If α_k is uniquely determined through marketable permit transfers for given cost function of advanced treatment, then correspondent relation between eq. (3) and eq. (11) gives the conclusion that $x_{i,k}$

in effluent charge system and $x_{i,k}$ in water quality trading system could be equalized to each other by adjusting parameters α_k, β_k and g as follows:

$$\alpha_k = \frac{\beta_k}{1-g} \tag{12}$$

The total sum of the net cost Y is expressed as follows;

$$Y = (1-g)\sum_{i=1}^{n} c_i + \sum_{i=1}^{n}\sum_{k=1}^{m} \beta_k x_{i,k} \tag{13}$$

Taking eq. (11) into account,

$$\frac{\partial Y}{\partial x_{i,k}} = (1-g)\frac{\partial c_i}{\partial x_{i,k}} + \beta_k = -\beta_k + \beta_k = 0 \tag{14}$$

which means that Y is minimized.

Since the source of subsidies is the collected effluent charges, total sum of subsidies could be equal to total collected charges as:

$$g\sum_{i=1}^{n} c_i = \sum_{i=1}^{n}\sum_{k=1}^{m} \beta_k x_{i,k} \tag{15}$$

$$\therefore \quad Y = (1-g)\sum_{i=1}^{n} c_i + \sum_{i=1}^{n}\sum_{k=1}^{m} \beta_k x_{i,k} = \sum_{i=1}^{n} c_i \tag{16}$$

This means that total cost of advanced treatment is minimized as well as total sum of net cost.

From eq. (12) and eq. (15), we have:

$$\beta_k = \frac{\alpha_k \sum_{i=1}^{n} c_i}{\sum_{i=1}^{n} c_i + \sum_{i=1}^{n}\sum_{k=1}^{m} \alpha_k x_{i,k}} = \frac{\alpha_k C}{C + \sum_{k=1}^{m} \alpha_k X_k} \tag{17}$$

$$g = \frac{\sum_{i=1}^{n}\sum_{k=1}^{m} \alpha_k x_{i,k}}{\sum_{i=1}^{n} c_i + \sum_{i=1}^{n}\sum_{k=1}^{m} \alpha_k x_{i,k}} = \frac{\sum_{k=1}^{m} \alpha_k X_k}{C + \sum_{k=1}^{m} \alpha_k X_k} \tag{18}$$

When the market equilibrium conditions $x_{i,k}$, c_i and α_k are known for any i and k in the water quality trading, then the effluent charge system which has the same results of $x_{i,k}$ and c_i as the water quality trading could be obtained by eq. (17) and eq. (18).

Although the mathematics for both the effluent charge system and water quality trading suggests an equivalent cost-effectiveness in meeting a predetermined target, their practical difference is how the uniform charge rate or transferable permit price is determined. As is clear from the discussions above, water quality trading system could be easily designed on the basis of the total sum of permits which is the predetermined target of the policy, while effluent charge system cannot be designed directly from the target.

4-2 Equality of Unit Net Cost

Discussions of economic instruments for water pollution control sometimes focus on equity as well as on cost-effectiveness. Equality of unit net cost is assumed to be an indicator of the equity between WWTPs and the equality can be quantitatively evaluated by the standard deviation of unit net costs for advanced treatment. Smaller value of the standard deviation might well be perceived as stronger equity.

Putting eq. (17) and eq. (18) into eq. (9), we have:

$$y_i = \frac{C}{C + \sum_{k=1}^{m} \alpha_k X_k}(c_i + \sum_{k=1}^{m} \alpha_k x_{i,k}) = (1-g)(c_i + \sum_{k=1}^{m} \alpha_k x_{i,k}) \qquad (19)$$

Therefore, unit net cost y_i/q_i in effluent charge system is expressed as follows;

Effluent charge system : $y_i/q_i = (1-g)\dfrac{c_i + \sum_{k=1}^{m} \alpha_k x_{i,k}}{q_i}$ (20)

Next, let baseline load $L_{i,k}$ be expressed as follows:

$$L_{i,k} = q_i r_k \qquad (21)$$

which means that r_k the baseline concentration of the constituent k is constant among WWTPs. This condition seems reasonable from the viewpoint of equity.

Then, from eq. (1) in water quality trading,

Water quality trading : $y_i/q_i = \dfrac{c_i + \sum_{k=1}^{m} \alpha_k x_{i,k}}{q_i} - \sum_{k=1}^{m} \alpha_k r_k$ (22)

Comparing eq. (20) with eq. (22), we have:

$$\sigma_C = (1-g)\sigma_T \prec \sigma_T \qquad (23)$$

This means that effluent charge system is reasonably estimated to be superior to water quality trading in terms of equity.

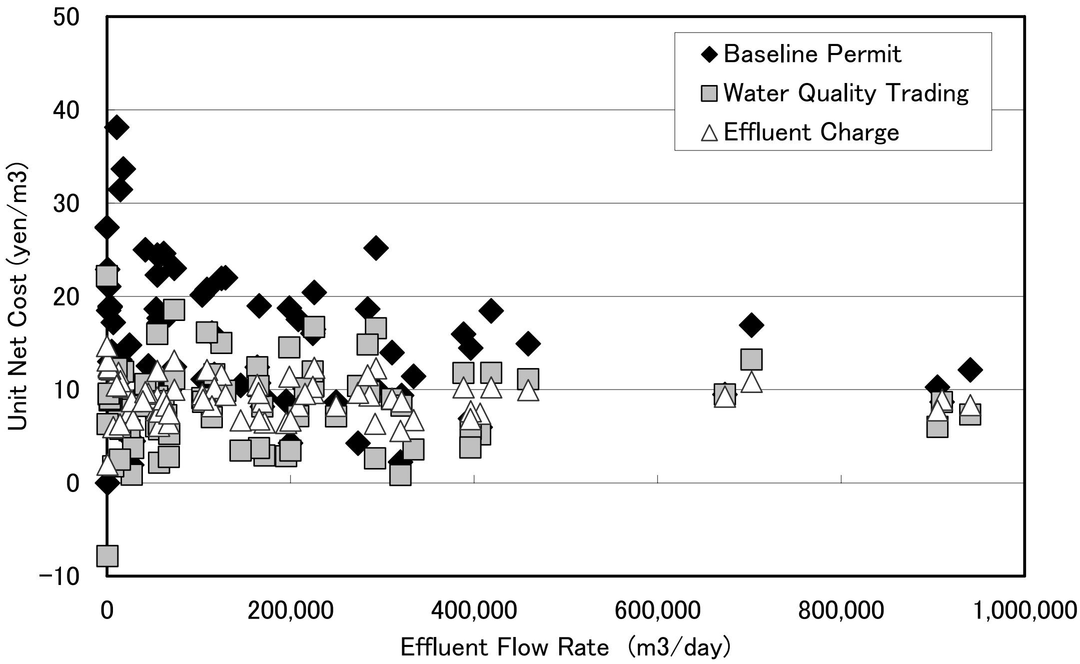

Figure 4 : Relation between Unit Net Cost And Effluent Flow Rate to Evaluate The Equality of Unit Net Cost

Figure 4 shows the Difference in equality between Baseline Permit, Water Quality Trading and Effluent Charge System, which is estimated by a case study of the simulation for Tokyo Bay basin

(See Appendix Ⅱ). Here, we have $\sigma_C = 2.3(\text{yen/m}^3)$, $\sigma_T = 4.7(\text{yen/m}^3)$, $g=0.57$, and so eq.(23) is approximately valid as $\sigma_C = 2.3 \approx (1-0.57)\times 4.7 = 2.021$.

4-3 Reflection of Local Conditions

Discussions have been held so far on the assumption that every WWTP has no motive of advanced treatment other than water pollution control for targeted water area. But in reality some local entities might have stronger motive because they wish more for clean water in targeted or other water areas for the benefit of their citizens. Other local entities might be willing to forward the advanced treatment for beneficial use of the effluent. Since the behaviours of WWTPs are influenced by their local conditions as well as the predetermined target common to all the WWTPs, reflection of local conditions is an important point of view from which the comparison could be made between effluent charge system and water quality trading.

Let us add a term of local conditions s_i as a function of x_i to eq. (1) ,

$$y_i = c_i + \sum_{k=1}^{m} \alpha_k (x_{i,k} - L_{i,k}) + s_i \qquad (24)$$

From the equilibrium condition : $\dfrac{\partial y_i}{\partial x_{i,k}} = \dfrac{\partial c_i}{\partial x_{i,k}} + \alpha_k + \dfrac{\partial s_i}{\partial x_{i,k}} = 0 \qquad (25)$

Water quality trading : $\dfrac{\partial c_i}{\partial x_{i,k}} = -\alpha_k - \dfrac{\partial s_i}{\partial x_{i,k}} \qquad (26)$

As for the effluent charge system equivalent to the above water quality trading, we have

$$y_i = (1-g)c_i + \sum_{k=1}^{m} \beta_k x_{i,k} + s_i \; .$$

Therefore, eq. (11) is modified as:

Effluent charge system : $\dfrac{\partial c_i}{\partial x_{i,k}} = -\dfrac{\beta_k}{1-g} - \dfrac{1}{1-g}\dfrac{\partial s_i}{\partial x_{i,k}}$

$$= -\alpha_k - \frac{1}{1-g}\frac{\partial s_i}{\partial x_{i,k}} \qquad (27)$$

taking eq. (12) into account.

Since $\partial s_i / \partial x_{i,k}$ is assumed to be positive and marginal cost related to load reductions is expressed as $-\partial c_i / \partial x_{i,k}$, comparing eq. (26) with eq. (27) gives the relation as follows:

(marginal cost for water quality trading)
$\prec$ (marginal cost for effluent charge system) (28)

This means that local conditions are more likely to be reflected in the advanced treatment in effluent charge system than in water quality trading. In other words, effluent charge system is more favourable for local entities that want to forward advanced treatment for their own benefit than water quality trading.

5. Conclusion

Sewerage Law was amended in 2005 and a modified approach was established by introducing the concept of LRA for nitrogen and phosphorus in the basin of enclosed water bodies. Transferable LRA is supposed to play a role equivalent to transferable permit in the water quality trading employed in the U.S.. Modified approach with transferable LRA is expected to substantially abate externality-related difficulties to guide local entities toward advanced treatment, because local entities, which can take the choice of substituting for the other local entities or being substituted for by the other local entities on LRA, will be able to conform to the CBPSS more easily as a whole.

By means of theoretical comparison between effluent charge system (combined with subsidy) and water quality trading, the following conclusions are obtained:

(1) The mathematics for both the effluent charge system and water quality trading suggests an equivalent cost-effectiveness in meeting a predetermined target. Effluent charge system equivalent to a water quality trading could be theoretically obtained from the result of water quality trading.

(2) Water quality trading could be easily designed on the basis of the total sum of permits which is the predetermined target of the policy, while effluent charge system cannot be designed directly from the target.

(3) According to the comparison of the standard deviations of unit net cost, effluent charge system is estimated to be superior to water quality trading in terms of equity.

(4) Local conditions are more likely to be reflected in the advanced treatment in effluent charge system than in water quality trading. In other words, effluent charge system is more favourable for local entities which want to forward advanced treatment for their own benefit than water quality trading.

6. Acknowledgement

The author would like to express the deepest appreciation for the useful advises toward the Study Committee on Water Quality Trading for Pollution Control in Enclosed Waters (Chairman : Prof. Kazuhiro Ueta, University of Kyoto).

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Appendix Ⅰ

Notation

c_i : Cost of advanced treatment for WWTP i,

C : Total cost of advanced treatment $(= \sum_{i=1}^{n} c_i)$,

g : Subsidy rate $\quad (0 \prec g \prec 1)$

$L_{i,k}$: Baseline Load of constituent k for WWTP i,

q_i : Effluent flow rate for WWTP i,

r_k : Baseline concentration of constituent k,

s_i : Cost related to local conditions for WWTP i,

$x_{i,k}$: Load of constituent k discharged from WWTP i,

X_k : Total load of constituent k from WWTPs $\left(= \sum_{i=1}^{n} x_{i,k}\right)$

y_i : Net cost for WWTP i,

Y : Total sum of net cost $\left(= \sum_{i=1}^{n} y_i\right)$

α_k : Price of transferable permit for constituent k,

β_k : Rate of effluent charge for constituent k,

σ_C : Standard deviation of unit net cost in effluent charge system,

σ_T : Standard deviation of unit net cost in water quality trading

Appendix Ⅱ

Case Study for Tokyo Bay

Case study of water quality trading was conducted focusing on Tokyo Bay. Constituents of pollutant were COD, total nitrogen and total phosphorus. By means of computer simulation, transferable permit of each constituent was separately traded among 75 WWTPs in the basin. Ten kinds of advanced treatment options were assumed including conventional method without advanced treatment. Before trading, advanced treatment costs, which consisted of depreciation and maintenance costs, are calculated for every treatment option of each WWTP, taking into account the flow rate, present treatment method and the difficulties in acquiring new site for treatment facilities. Baseline concentration as well as flow rate of each WWTP was set referring to the study report of CBPSS for Tokyo Bay. In the computer simulation, prices are tentatively set at first and then optimum option of advanced treatment, i.e. buying/selling permit or their combination is selected for every WWTP so that the net cost may be minimized. At the end of the algorithmic procedure, permit demand and permit supply are checked with each other. This procedure is continued until the cost for buying supply surplus that should be non-negative for every constituent is minimized.

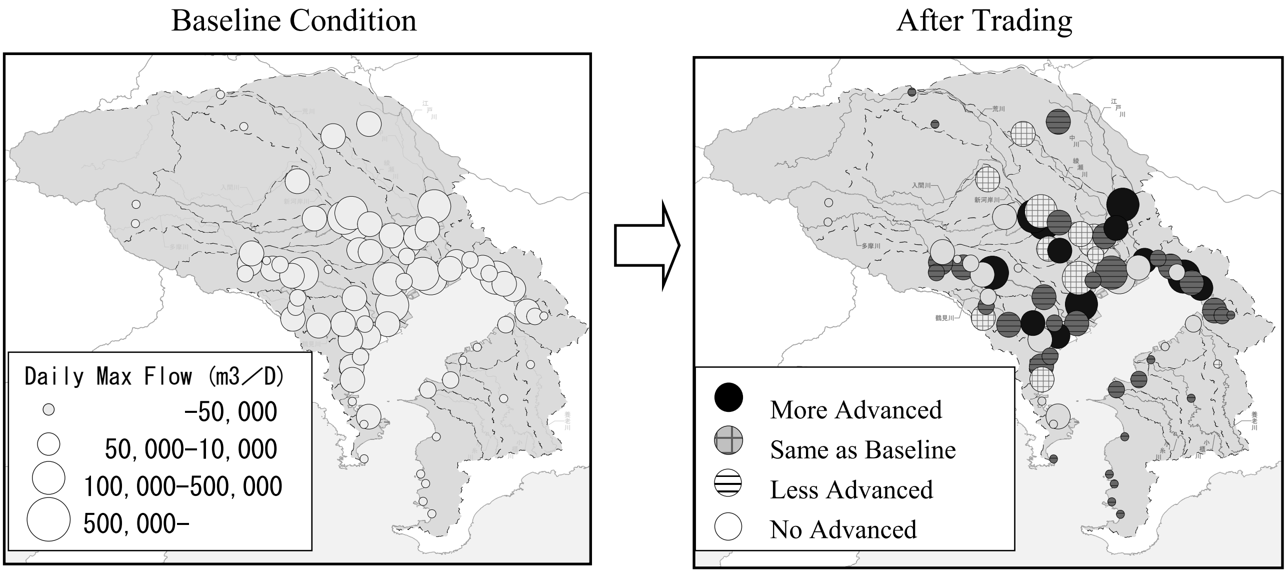


Figure 5 : Shift in Advanced Treatment Level through Water Quality Trading

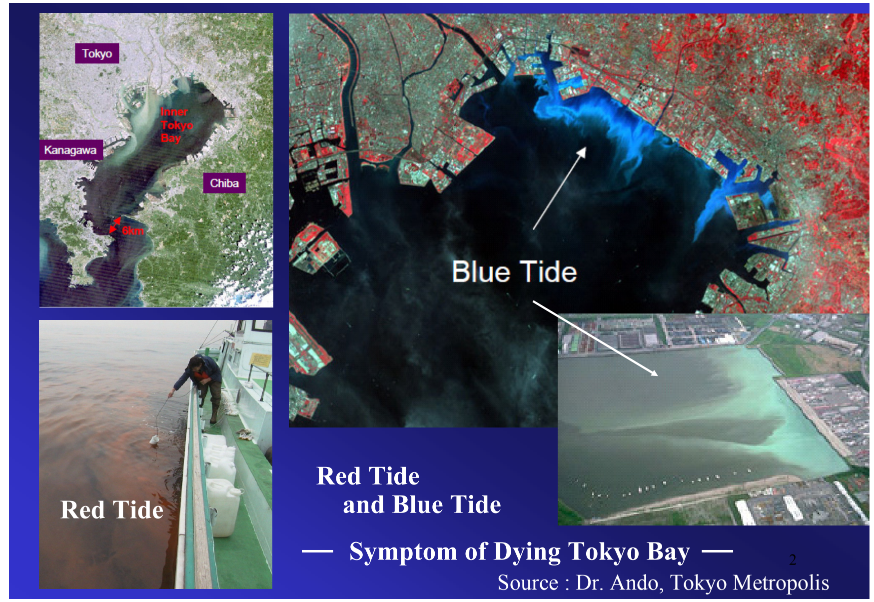
Figure 5 shows the result of the computer simulation. Each circle whose scale indicates effluent flow rate corresponds to WWTP. The circle signs in the left figure show how the WWTPs change their attitudes toward advanced treatment from the baseline as a consequence of trading. The cost abatement rate of water quality trading throughout the basin is estimated to be 31% as shown in Table 1.

Table 1 : Total Cost of Advanced Treatment (million yen/year)

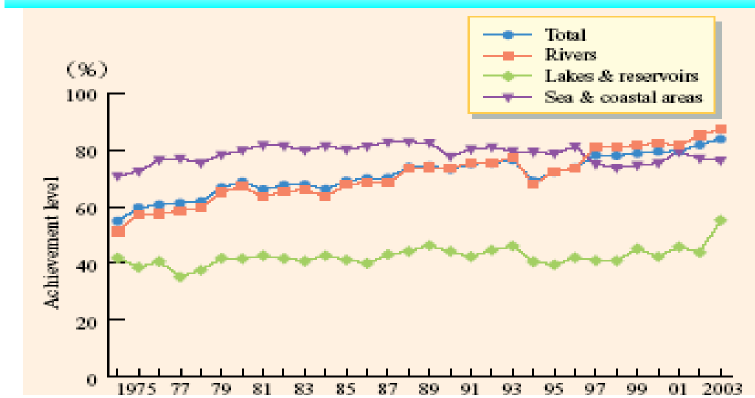
Baseline Permit	After Trading	Cost Abatement Rate
65,916	45,792	31%

(Simulated for WWTPs in Tokyo Bay basin)

The effluent charge system that is designed equivalently to above water quality trading based on eq. (17) and eq. (18) is also simulated by computer. Figure 4 is obtained by the results of the simulations.



Achievement of Environmental Water Quality Standard



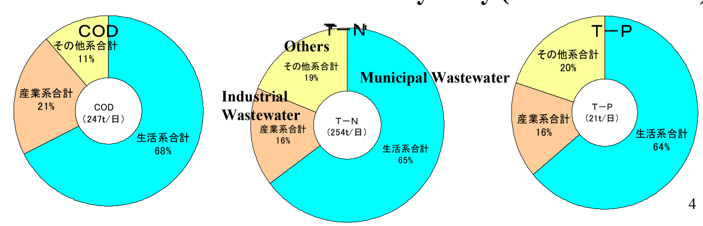
Notes :
1.BOD used for rivers, and COD used for lakes/reservoirs, and sea/coastal areas.
2.Achievement level (%)=(no. of water bodies achieving / no. of designated water bodies)×100

Source : Ministry of Environment

Pollution Sources of Three Big Bays and Present State of Sewage Works

	Rate of the Population Served with Sewerage		Rate of Advanced Treatment (Removal of N and/or P)	
	Target	As of 2003	Target	As of 2003
Tokyo Bay	95.7	87.6	92.8	3.6
Ise Bay	93.0	57.0	92.7	17.3
Osaka Bay	95.4	85.7	94.7	14.1

Pollution Source Structure of Tokyo Bay (As of Fiscal 1999)



Why Advanced Treatment Not in Progress ?

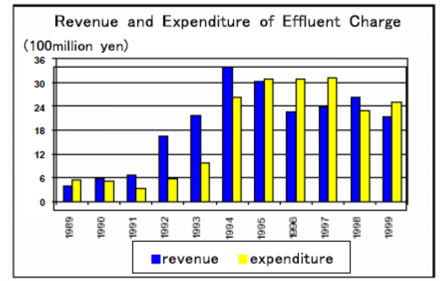
5

Effluent Charge System in Germany

The fund collected through effluent charge is allocated for water resources and environment.

Year	Effluent Charge for Unit Pollution Load	
1981.1	12 DM	720 yen
1982.1	18 DM	1,080 yen
1983.1	24 DM	1,440 yen
1984.1	30 DM	1,800 yen
1985.1	36 DM	2,160 yen
1986.1	40 DM	2,400 yen
1991.1	50 DM	3,000 yen
1993.1	60 DM	3,600 yen
1997.1	70 DM	4,200 yen
2002.1	35.79 EURO	4,200 yen

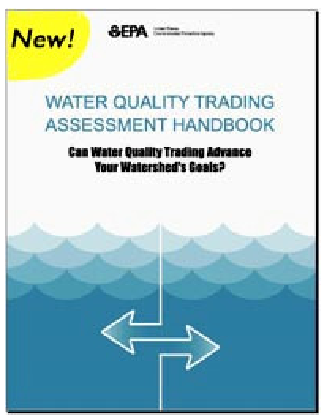
Revenue and Expenditure of Effluent Charge in Schleswig-Holstein State



Source : Yambe (NGK)

Water Quality Trading

Market-based approach to improve and preserve water quality



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- Sewerage construction/improvement programs shall be made and implemented "in accordance with" the relevant CBPSS
- But
- CBPSS could not function as strict command-and-control measures.
- Because
- Sewerage Law postulates that CBPSS should be formulated taking cost-effectiveness into account and it is very difficult to satisfy this condition.

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More theoretically

- Basin-wide cost-effectiveness is guaranteed on the condition of the equalization of marginal reduction costs across all the WWTPs in the basin. However prefectures formulating CBPSS cannot determine the marginal reduction costs beforehand in reality.
- Therefore
- Command-and-control method cannot be easily applied on the basis of CBPSS.

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Modified Approach

- Sewerage Law was amended in 2005 and a modified approach was established
- A. Determination of the Baseline LRA
- Prefecture shall determine the baseline LRA (Load Reduction Assignment) for nitrogen or phosphorus contained in the effluent of relevant WWTPs in the CBPSS which targets on enclosed water bodies where EWQS (Environmental Water Quality Standard) of nitrogen or phosphorus is set.
- B. Cooperation for Advanced Treatment between Local Entities
- B-1 Proposal of Substitution
- Local entity can submit to the prefecture a proposal that it will substitutively fulfill the LRA assigned to the other entity's WWTP, after reaching the agreement with the local entity to be substituted for on this issue.

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- B-2 Registration in CBPSS
- The prefecture that has received the proposal of substitution can register the information of the substitution including the estimated cost and its sharing in the CBPSS.
- B-3 Payment for Substitution
- The local entity that substitutively fulfills the LRA assigned for the other entity's WWTP can, as the legal effect of the registration in CBPSS, make the entity to be substituted for pay the cost for the substitution including the cost of construction, improvement, rehabilitation, repair, maintenance and control.

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Equivalency between Modified Approach and Water Quality Trading

Modified Approach in CBPSS (Japan)		Water Quality Trading (U.S.A.)
Transferable LRA (Load Reduction Assignment)	⟷	Transferable Permit for Discharging Pollutant
Substituting for the other WWTP on LRA	⟷	Selling Transferable Permit
Being substituted for by the other WWTP on LRA	⟷	Buying Transferable Permit

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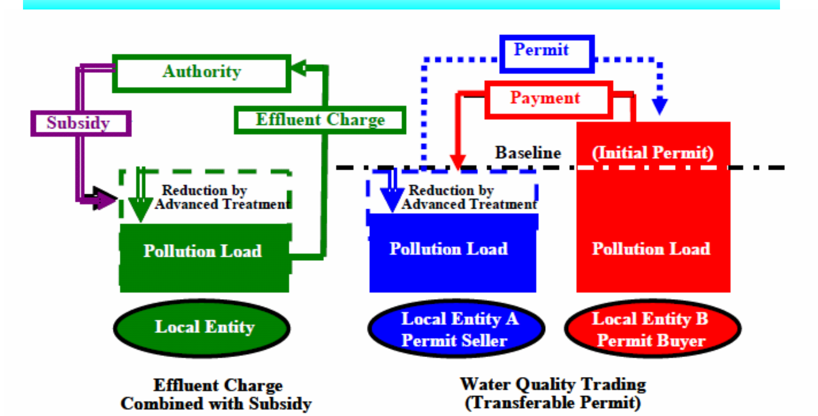
Schematic Diagram of the Two Types of Economic Instruments



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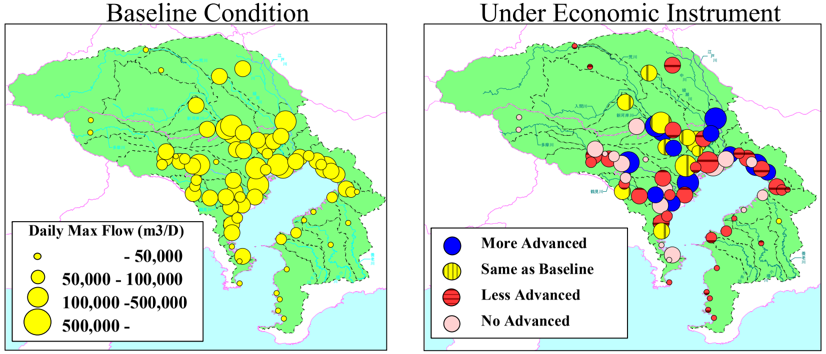
1. Equivalency in cost-effectiveness

- The mathematics for both effluent charge system and water quality trading suggests an equivalent cost-effectiveness in meeting a predetermined target.

$$\frac{\partial c_i}{\partial x_{i,k}} = \frac{\partial c_j}{\partial x_{j,k}} = -\alpha_k \ \text{: constant for every WWTP}$$

Marginal cost for advanced treatment is equalized to for every WWTP in both approaches.

Shift in Advanced Treatment Level
- Result of Computer Simulation for Tokyo Bay -



Total Cost of Advanced Treatment (million yen/year)

Baseline Permit	Under Economic Instrument	Cost Abatement Rate
65,916	45,792	31%

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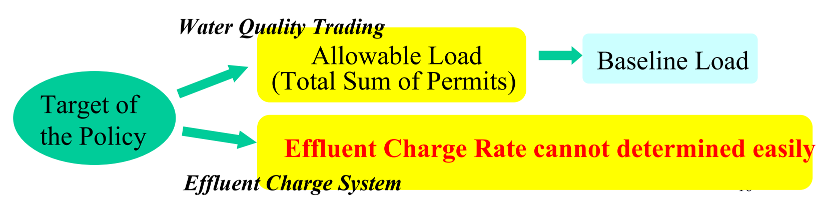
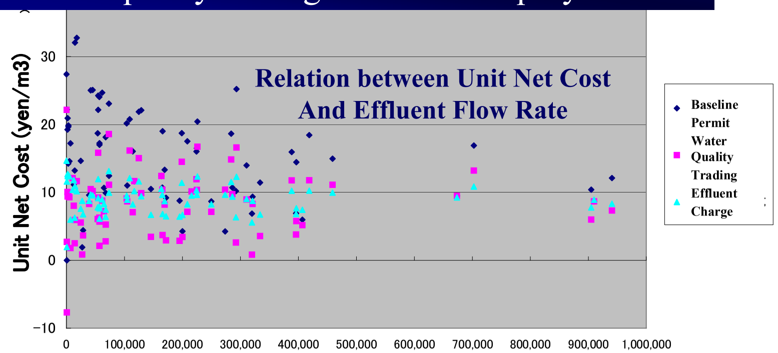
2. System Designing

Water quality trading could be easily designed on the basis of the total sum of permits which is the predetermined target of the policy, while effluent charge system cannot be designed directly from the target.



3. Equity

Effluent charge system is estimated to be superior to water quality trading in terms of equity.



Effluent Flow Rate (m^3/D)

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4. Equity

Local conditions are more likely to be reflected in the advanced treatment in effluent charge system than in water quality trading.

Effluent charge system is more favourable for local entities which want to forward advanced treatment for their own benefit than water quality trading.

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5. Public Acceptance / Resistance