ENVIRONMENTAL ACCOUNTING HOUSEKEEPING (EAH) BOOKS OF DOMESTIC WASTEWATER: A CASE STUDY OF CHIBA CITY, CHIBA PREFECTURE, JAPAN

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1. INTRODUCTION

Several programs and projects have been conducted in the field of international marine water pollution. Global Programme of Action (GPA) for the Protection of the Marine Environment from Land-based Activities was established in 1995 for the purpose of investigation and activities of countermeasures against marine pollution (UNEP, 2003). Global International Waters Assessment (GIWA) led by UNEP and conducted by Kalmar University, Sweden conducted researches in 66 coastal area and enabled Global Environment Facility (GEF) budget used in the marine environment protection. Prior to these programs, UNEP has launched Regional Seas Programme in 1974 after UN Environment Summit (Rio-De-Janeiro, Brazil) in 1972. More than 140 countries are participating programs and/or agreements on marine water pollution (UNEP/GPA Coordination Office, 2002).

In the United States, a Total Maximum Daily Load (TMDL) has been introduced pollutant reductions policy (EPA, 2004). States report over 40 percent of assessed waters are still too polluted for fishing or swimming even after 28 years of water pollution control effects. TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. In Japan, gross pollutant loads control policy has been developed to control pollutant loads flowing into the enclosed coastal zones (National Environmental Conference, 1999). In European countries, England, urban runoff and wastewater pollutant reduction manual has been prepared in 1998. In Germany,

In regards to land based water pollutants flowing into Tokyo Bay, much portions are occupied by domestic wastewater (ex. Ministry of Environment, 2002), which is similar circumstances for many enclosed coastal zones especially along the developed countries, in which industrial wastewater treatment measurements have been advanced. Therefore, measurements to reduce the domestic wastewater pollutant loads are considered to be effective to reduce total pollutant loads running into Tokyo Bay.

In regards to domestic wastewater treatment and urban river water, domestic wastewater pollutants reduction measurements at kitchen have been said to reduce BOD and COD discharge by 20-30% (Ogura ed., 1993). Water quality of urban river water is considered not to improve so much in a decade while pollutant loads reduction measurements of domestic wastewater are introduced (Sudo, 2000). This paper highlights quantitative relations between pollutant emissions derived from domestic wastewater and pollutant loads in the rivers.

Pollutants reduction effect in the rivers have been studied by many researchers including established classical research by Streeter and Phelps (1943) including reaction velocity coefficients. Many researches on pollutant purification reaction have been conducted (Sueyoshi, 1977). Pollutant loads and pollutant emissions have also been studied by many researchers (Fujita, 1999).

As dissemination and environmental education methods in the fields of river and coastal zone water pollution problems, miscellaneous activities including clean up activities along rivers and coastal lines and committees on water environments in which citizens are participating have been held. It is sometimes pointed out that wastewater treatment plants (WTP) are pollutant load sources. It is not mistake, however, more scientific approach and quantitative information dissemination would be preferable in regards to the diversities of characteristics of drainage areas and performances of domestic wastewater treatment methods. To elaborate such participations by citizens, I think, as a professional, quantitative information dissemination would be useful for ordinary citizens to decide on their participations.

Pollutant loads per capita flowing into a tidal coastal zone (Tsuzuki and Ogawa, 2004; Tsuzuki 2004b) are more friendly and easy indexes to be understood by citizens.

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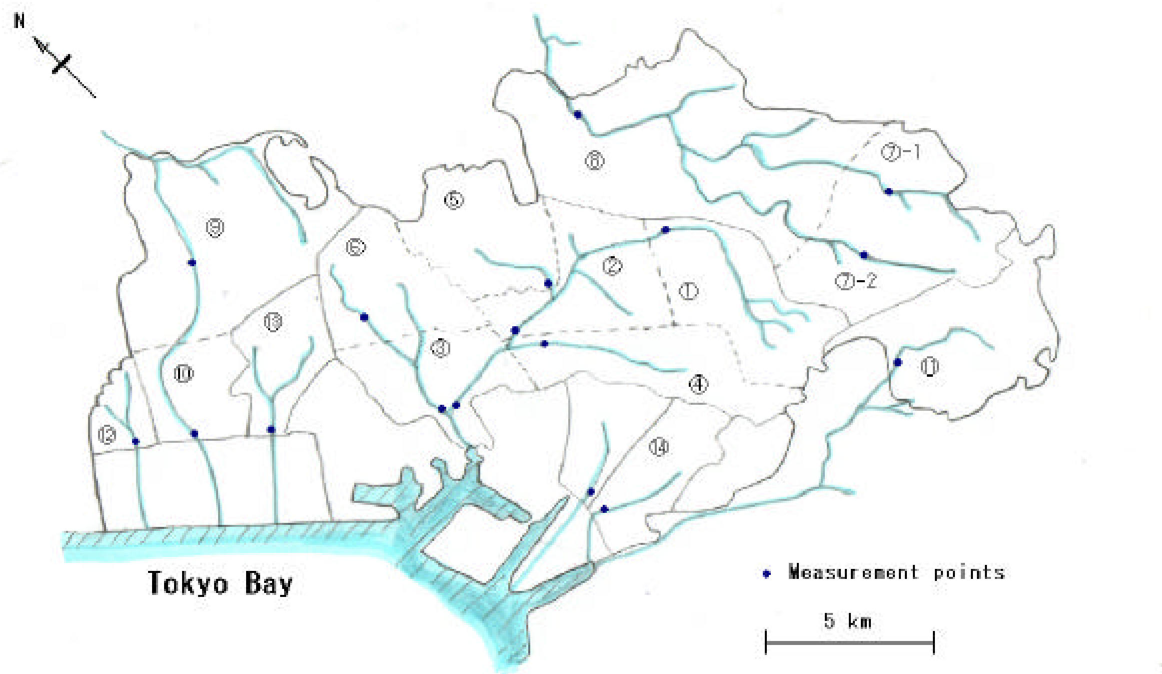

Drainage area No.	Drainage area	Measurement points
1	Miyako River, upper drainage area	Takanebashi Bridge
2	Miyako River, middle drainaga area	Aoyagibashi Bridge
3	Miyako River and Yoshikawa River, lower drainage area	Miyakobashi and Nihonbashi Bridges
4	Miyako River, branch stream	Shin-Miyakobashi Bridge
5	Sakatsuki River	Nabetamaebashi Bridge
6	Yoshikawa River, upper drainage area	Chiba Municipal Zoo
7-1	Kashimagawa River, upper drainage area	Simo-Ohwada
7-2	Hirakawa River, upper drainage area	Hirakawabashi Bridge
8	Kahimagawa River and Hirakawa River, middle and lower drainage area	Simoizumibashi Bridge
9	Hanamigawa River, upper drainage area	Hanashimabashi Bridge
10	Hanamigawa River, lower drainage area	Shin-Hanamigawabashi Bridge
11	Muratagawa River	Takamotodanibashi Bridge
12	Hamadagawa River	Simo-Yasakabashi Bridge
13	Hanazonogawa River (Kusano water stream)	Takasubashi Bridge
14	Hamanogawa River	Hamanobashi Bridge

Fig.1 Rivers, drainage areas and measurement points in Chiba City.

Domestic wastewater management manuals or environmental accounting housekeeping (EAH) books of domestic wastewater will be effective tools for citizens to reduce water pollutant loads (Tsuzuki and Ogawa, 2004; Tsuzuki, 2004b). EAH books for reduction of CO_2 emission as a countermeasure to the global climate change are examples of administrative measurements to reduce pollutant loads emission from municipal lives, which are introduced in Japan by local governments, environmental NGOs, companies and so on.

While output of EAH books for CO_2 reduction is one parameter, i.e. CO_2 waste amount, those of domestic wastewater would be a few parameters including BOD, COD, T-N and T-P. This is a little complicated characteristics, however, it would be a worth tool to let ordinary citizens to understand complicated aspects of water pollution problems. Important and necessary points for the preparation of EAH books for domestic wastewater have been considered as the followings: (1) tables are prepared for each domestic wastewater treatment method; (2) basic parameters of water quality are COD (or BOD), T-N and T-P; (3) citizens can easily fill the tables with the effective actions to reduce pollutant loads; (4) pollutant loads reduction effects can be easily calculated; and (5) EAH books should be prepared for each drainage area, because pollutant loads per capita running into coastal zones or rivers by wastewater treatment methods are dependent on the drainage area.

In this paper, pollutant loads per capita flowing into public waterbodies was analyzed in the drainage areas in Chiba City, Chiba Prefecture, which faces Tokyo Bay, mainly to conduct comparative study on the index and to obtain

Table 1 Information sources for the analyses in this paper.

Targeted items	Data and Information Sources (in Japanese)
Pollutant loads of the rivers	Chiba City, 1997: Pollutant loads analysis tables, p.37, *in* Report of basic research for preparation of environment reservation plan, 218p. Chiba City, 1999: Environment reservation plan, 146p. Chiba City, 2004: Rivers and sea in Chiba City, http://www.city.chiba.jp/ env/water/suisitu/index.htm. (Accessed on 1st Aug., 2004)
Population by wastewater treatment methods	Chiba City, 1997: Pollutant loads analysis tables, p.37, *in* Report of basic research for preparation of environment reservation plan, 218p.
Pollutant removal rates at WTPs	Chiba Prefecture Wastewater Treatment Corporation Foundation, 1998-2002: Imbanuma drainage area wastewater treatment system Hanamigawa second WTP maintenance and management annual report. Wastewater Treatment Bureau of Chiba City, 2003: Wastewater Treatment in Chiba City, 132p.
Water pollutant reduction effects in households	Funabashi City, 2000: Leaflet, Funabashi city promotion plan of domestic wastewater measurement, Diet Water, Housewife Mariko's domestic wastewater measurements manual, 10p.

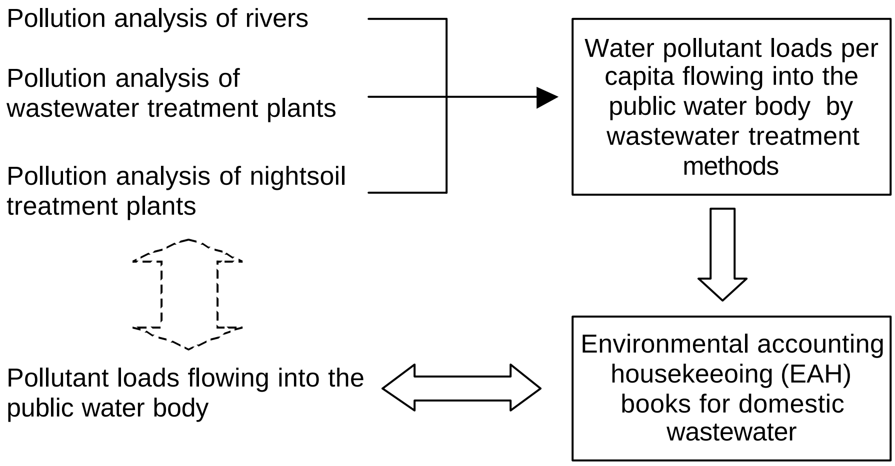

Fig.2 Overall framework of the pollutant loads analysis of domestic wastewater. (Modified from Tsuzuki, 2004b)

basic data to prepare EAH books of domestic wastewater in Chiba City area.

2. METHODS

2.1 Overall Framework of the Pollutant Loads Analysis

There are 17 drainage areas defined by administrative in Chiba City, of which 14 drainage areas are subjected in this study (Fig .1). Total area of 14 drainage areas subjected in this study was 218 km^2, population was 607,500 persons, and population density was 2,784 persons $km^{2\ -1}$. Areas of 14 drainage area were 6.1-38.1 km^2, populations were 6,200-117,400 persons, and population densities were 297-9,630 persons $km^{2\ -1}$.

Pollutant loads per capita of organic carbon flowing into public water body were calculated in these drainage areas based on the available data and information (Table 1) except for some areas with difficulty of calculation because of data deficiency or geological reason. BOD and COD are analyzed in this research because of their data availability. The data investigated were water quality and quantity data in 1994, when the Water Environment Preservation Plan of Chiba City (Chiba City, 1999) was based on the basic water quality and quantity data. Overall framework of the pollutant loads analysis and EAH books of domestic wastewater in this paper is summarized in Fig. 2.

2.2 Pollutant Emissions by Domestic Wastewater Treatment Methods

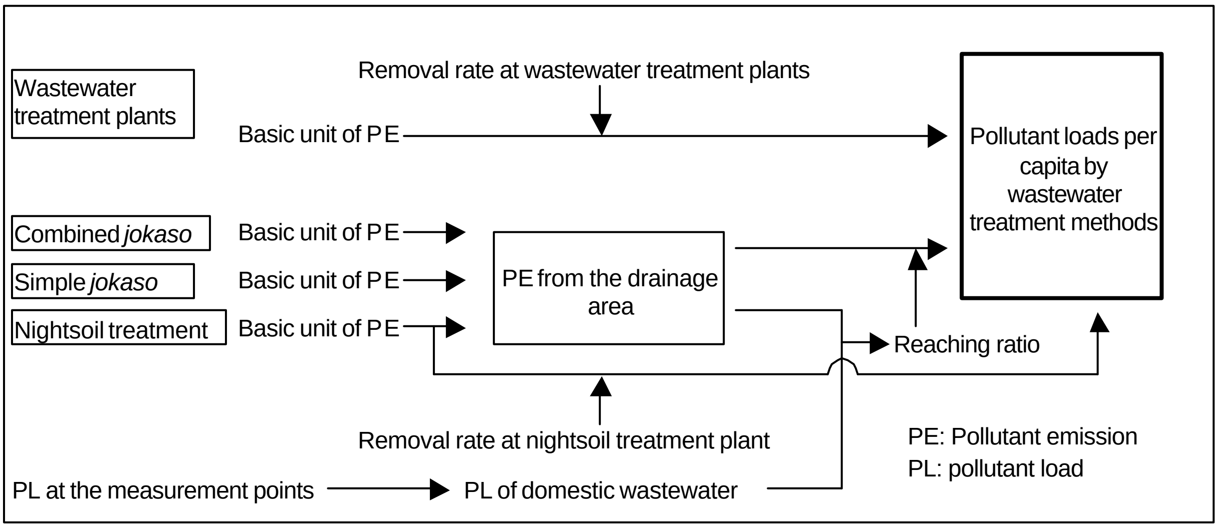

Fig. 3 Flow chart of pollutant loads per capita analysis. (Modified from Tsuzuki, 2004b)

Pollutant emissions of domestic wastewater were calculated based on the basic units of pollutants and removal rates of each domestic wastewater treatment methods. Basic units of domestic wastewater pollutant loads are derived from Fujimura and Nakajima (1998). There are four WTP treating domestic wastewater in Chiba City, Hanamigawa River 1st and 2nd, Central and South WTP. BOD, COD, T-N and T-P removal rates were calculated as weighted average by treatment amount of the four WTP, based on the WTP management data (Table 1) and WTP populations of the drainage areas (Table 1). For combined and simple *jokaso* and night soil treatment population, basic discharge units is derived from Fujimoto (1988) and Fujimura (1996). Polluntant emissions other than domestic wastewater including nonpoint sources and livestock wastewater were derived from the administrative data (Table 1).

BOD loads in the river were calculated using three-year average from 1993 to 1995 of BOD concentration and flow rate estimated from those in 1990 and 2000. BOD emissions in the drainage areas were calculated based on the administrative data on basic research for the municipal water environmental preservation planning (Table 1). Reaching ratios of the measurement points were calculated by three methods: 1) pollutant loads in the river of drainage area(s) above the measurement points and total pollutant emissions above the measurement points, 2) pollutant loads in the river of each drainage area and emissions in each drainage area, and 3) pollutant loads above the measurement points and pollutant emissions above the measurement points. Pollutant load per capita was calculated only when the calculated reaching ratio was from zero to 100%. In the first and second calculation above, the measurement points in the drainage area are supposed to positioned at the end of the drainage area, i.e. all the pollutant emissions in the drainage area are flowing into the measurement points. In the third calculation, the percentages of the pollutant emissions above and below the measurement points in the drainage area were considered. The values of the percentages were voluntarily determined from the geological area above and below the measurement points.

For the third method, the following calculations with equations (1) to (3) were conducted. Emission loads in a drainage area was calculated as emission loads in the upper area of the measuring point of the each drainage area with the following equation (1):

$$PE = PEj \times \frac{Aja}{Aj} \qquad (1)$$

where
PE: pollutant emissions above the measurement point in a drainage area (kg day^{-1}),
PE_j: total pollutant emissions in a drainage area (kg day^{-1}),
A_{ja}: area above the measurement point in the drainage area (km^2), and
A_j: total area in the drainage area (km^2).

For drainage areas which have upper drainage area(s), total pollutant emissions were calculated with the following equation (2):

$$PE = \sum_i PEi + PEj \times \frac{Aja}{Aj} \qquad (2)$$

Table 2 Pollutant emissions of pollutant loads per capita by domestic wastewater treatment methods, which are emitted into wastewater treatment plants or public water bodies. (Calculated by author based on Fujimura and Nakajima, 1998, Fujimoto, 1988 and Fujimura, 1996)

Pollutant Emission from domestic wastewater (g $person^{-1}$ day^{-1})	BOD	COD	TN	TP
Basic units of domestic wastewater	45	23	8.5	1.0
Night soil	16	10	7.0	0.70
Kitchen, bath, washing clothes etc.	29	13	1.5	0.30
Emission of wastewater treatment plant population	45	23	8.5	1.0
Emission of combined *jokaso* population	3.2	4.6	7.0	0.88
Emission of simple *jokaso* population	32.2	16.5	7.5	0.97
Emission of simple *jokaso* population derived from night soil	3.2	3.5	6.0	0.67
Emission of night soil treatment population	29	13	1.5	0.30

Table 3 Pollutant load per capita and other parameters for WTP population.

Parameters for WTP population / Water quality	BOD	COD	TN	TP
Pollutant emission per capita (g $person^{-1}$ day^{-1})	45	23	8.5	1.0
Removal rate at WTP (%)	98.1	90.1	60.5	69.1
PL[1)] per Capita flowing into public water body (g $person^{-1}$ day^{-1})	0.83	2.3	3.4	0.31

Note: 1) PL: pollutant load

For drainage area with a river water or wastewater treatment facility including a riverside purification facility and a agriculture village wastewater purification facility, pollutant emission of the drainage area was calculated using the removal rate of each facility and treated and untreated river water or wastewater volume in the treatment facility using the following equation (3):

$$PE = PEj \times \frac{\{(1-R) \times Qi + Qj\}}{Qi + Qj} \qquad (3)$$

where
R: removal rate of the treatment facility (-),
Q_i: treated river water or wastewater volume in the treatment facility (m^3 day^{-1}), and
Q_j: untreated river water or wastewater volume in the treatment facility (m^3 day^{-1}).

The values of R were supposed to be 0.80 for BOD and 0.70 for COD, respectively, and Q_i and Q_j were supposed to be equal volumes, i.e. a half of the subjected river water or wastewater was supposed to be treated by a treatment facility in this study. Natural purification effect in the river was considered as the reaching ratios in the drainage areas in this study.

COD loads in the rivers were calculated using the following equation (4) derived from BOD (5.9-37 g-BOD m^{-3}) and COD (8.1-31 g-COD m^{-3}) data of similar inner city rivers.

$$COD = 0.4682 \times BOD + 5.6338 \qquad (4)$$

(N = 289, R^2 = 0.6642)

The calculation methods of the reaching ratios of the measurement points were the same as those of BOD loads. COD load per capita was calculated only when the reaching ratio was between zero and a hundred.

2.3 Pollutant Loads per Capita by Domestic Wastewater Treatment Methods

Pollutant loads per capita flowing into public water bodies at each measurement point of the drainage area and each river mouth of drainage areas for combined *jokaso*, simple *jokaso* and night soil treatment populations were calculated based on the reaching ratios of domestic wastewater and pollutant emissions calculated above (Fig. 3). For night soil treatment population, pollutant loads through rivers and those through the treatment plants were added to obtain total pollutant loads per capita.

2.4 Environmental Accounting Housekeeping (EAH) Books of Domestic Wastewater

Formats of EAH books for domestic wastewater for WTP, combined *jokaso*, simple *jokaso* and night soil treatment populations were prepared based on the pollutant loads per capita flowing into public water body calculated above and some information on the reduction of pollutants loads from household activities (Table 1). The pollutant loads on which the EAH books were based were supposed to the populations weighted average of pollutant loads per capita flowing into public water body by the domestic wastewater treatment methods.

Table 4 BOD loads at the measurement points and BOD emissions in drainage areas.

Drainage area No.	BOD load at measurement points[1)]	BOD load of each drainage area	BOD emissions from drainage area	Total BOD emissions above measurement points	Reaching ratio[2)] (1) and (4)	Reaching ratio[2)] (2) and (3)	Reaching ratio[2)] Eqs(1)-(3)
	(kg-BOD day^{-1})				(%)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	200	200	506	506	39	39	44
2	1,065	447	490	1,812	59	91	141
3	1,577	-627	424	3,508	45	-148	66
4	326	326	572	572	57	57	63
5	418	418	816	816	51	51	51
6	814	814	701	701	116	116	166
7-1	107	107	188	188	57	57	118
7-2	136	136	191	191	71	71	143
8	237	-7	454	833	28	-1	38
9	942	942	1,264	1,264	75	75	124
10	749	-194	294	1,558	48	-66	-387
11	54	54	208	208	26	26	37
12	211	211	134	134	158	158	158
13	282	282	233	233	121	121	121
14	165	165	515	515	32	32	36
Sum	-	-	6,992	-	-	-	-

Note: 1) Three year average of BOD loads at measurement points between 1993 and 1995; 2) Reaching ratios were calculated using columns (1) and (4), columns (2) and (3) of Table 4, and equations (1)-(3), natural purification effect in the river was considered as the reaching ratios in the

Table 5 Reaching ratios and BOD loads per capita flowiing into public water bodies for combined *jokaso*, simple *jokaso* and night soil treatment population.

Drainage area No.	BOD loads per capita flowing into public water body[1)]								
	Calculated based on (5)			Calculated based on (6)			Calculated using Eqs (1)-(3)		
	Combined *Jokaso*	Simple *Jokaso*	Night soil treatment	Combined *Jokaso*	Simple *Jokaso*	Night soil treatment	Combined *Jokaso*	Simple *Jokaso*	Night soil treatment
	(g-BOD person^{-1} day^{-1})								
	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1	1.3	12.7	11.7	1.3	12.7	11.7	1.4	14.1	13.0
2	1.9	18.9	17.3	2.9	29.4	26.8	-	-	-
3	1.4	14.5	13.3	-	-	-	2.1	21.3	19.5
4	1.8	18.3	16.8	1.8	18.3	16.8	2.0	20.4	18.6
5	1.6	16.5	15.2	1.6	16.5	15.2	1.6	16.5	15.2
6	-	-	-	-	-	-	-	-	-
7-1	1.8	18.3	16.8	1.8	18.3	16.8	-	-	-
7-2	2.3	23.0	21.0	2.3	23.0	21.0	-	-	-
8	0.9	9.1	8.5	-	-	-	1.2	12.3	11.4
9	-	-	-	2.4	24.0	21.9	-	-	-
10	1.5	15.5	14.2	-	-	-	-	-	-
11	0.8	8.3	7.8	0.8	8.3	7.8	1.2	11.9	11.0
12	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-
14	1.0	10.3	9.6	1.0	10.3	9.6	1.1	11.5	10.6
Average[2)]	1.5	15.2	13.7	2.1	19.4	16.0	1.4	13.3	12.7
S.D.	0.5	4.6	4.1	0.7	6.8	6.2	0.4	4.1	3.7

Note: **1)** the subjected public water body is the measurement point in each drainage area, and removal rates of water purification facilities are not included in the values in the table; 2) Weighted average with population.

Table 6 COD loads at the measurement points and COD emissions in drainage areas.

Drainage area No.	COD load at measurement points[1)]	COD load of each drainage area	COD emissions from drainage area	Total COD emissions above measurement points	Reaching ratio[2)] (1) and (4)	Reaching ratio[2)] (2) and (3)	Reaching ratio[2)] Eqs(1)-(3)
	(kg-COD day^{-1})				(%)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	99.1	99.1	302.6	302.6	32.8	32.8	36.4
2	504.3	203.8	323.8	1,084.9	46.5	62.9	79.6
3	744.1	-305.0	271.5	2,201.8	33.8	-112.3	226.3
4	158.0	158.0	356.1	356.1	44.4	44.4	49.3
5	201.4	201.4	458.5	458.5	43.9	43.9	43.9
6	386.7	386.7	489.3	489.3	79.0	79.0	112.9
7-1	55.8	55.8	141.3	141.3	39.5	39.5	49.6
7-2	69.4	69.4	139.7	139.7	49.7	49.7	71.2
8	116.4	-8.8	352.5	633.5	18.4	-2.5	25.1
9	446.9	446.9	861.9	861.9	51.8	51.8	86.4
10	356.2	-90.6	177.0	1,038.9	34.3	-51.2	-393.0
11	30.8	30.8	156.8	156.8	19.6	19.6	28.1
12	104.6	104.6	88.5	88.5	118.2	118.2	118.2
13	137.8	137.8	200.8	200.8	68.6	68.6	68.6
14	83.0	83.0	315.4	315.4	26.3	26.3	29.2
Sum	-	-	4,639	-	-	-	-

Note: 1) Three year average of BOD loads at measurement points between 1993 and 1995; 2) Reaching ratios were calculated using columns (1) and (4), columns (2) and (3) of Table 6, and equations (1)-(3), natural purification effect in the river was considered as the reaching ratios in the drainage areas in this study.

Table 7 Reaching ratios and COD loads per capita flowiing into public water bodies for combined *jokaso*, simple *jokaso* and night soil treatment population.

Drainage area No.	COD loads per capita flowing into public water body[1)]								
	Calculated based on (5)			Calculated based on (6)			Calculated using Eqs (1)-(3)		
	Combined *Jokaso*	Simple *Jokaso*	Night soil treatment	Combined *Jokaso*	Simple *Jokaso*	Night soil treatment	Combined *Jokaso*	Simple *Jokaso*	Night soil treatment
	(g-COD person^{-1} day^{-1})								
	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
1	1.5	5.4	5.2	1.5	5.4	5.2	1.7	6.0	5.7
2	2.1	7.7	7.0	2.9	10.4	9.2	3.7	13.1	11.3
3	1.6	5.6	5.4	-	-	-	-	-	-
4	2.0	7.3	6.8	2.0	7.3	6.8	2.3	8.1	7.4
5	2.0	7.2	6.7	2.0	7.2	6.7	2.0	7.2	6.7
6	3.6	13.0	11.3	3.6	13.0	11.3	-	-	-
7-1	1.8	6.5	6.1	1.8	6.5	6.1	2.3	8.2	7.4
7-2	2.3	8.2	7.4	2.3	8.2	7.4	3.3	11.8	10.3
8	0.8	3.0	3.4	-	-	-	1.2	4.1	4.3
9	2.4	8.6	7.7	2.4	8.6	7.7	4.0	14.3	12.2
10	1.6	5.7	5.4	-	-	-	-	-	-
11	0.9	3.2	3.5	0.9	3.2	3.5	1.3	4.6	4.6
12	-	-	-	-	-	-	-	-	-
13	3.2	11.3	9.9	3.2	11.3	9.9	3.2	11.3	9.9
14	1.2	4.3	4.4	1.2	4.3	4.4	1.3	4.8	4.8
Average[2)]	1.7	6.1	5.8	1.2	4.0	4.3	3.0	9.6	7.4

Note: 1) the subjected public water body is the measurement point in each drainage area, and removal rates of water purification facilities are not included in the values in the table; 2) Weighted average with population.

3. RESULTS

3.1 Wastewater Treatment Plants (WTP) Population

Pollutant emissions of WTP population are the same as basic units of domestic wastewater based on the assumption that there are no degradation of organic carbon, T-N and T-P concentrations between houses and WTP (Table 2). Based on the management data and populations whose wastewater is treated by three WTP, removal rates were calculated as BOD: 98.1, COD: 90.1, T-N: 60.5 and T-P: 69.1%. Pollutant loads per capita flowing into public water body are calculated as shown in Table 3 based on the pollutant emissions and the removal rates. Pollutant loads per capita of WTP population flowing into public water body were calculated as 0.83 g-BOD person^{-1} day^{-1}, 2.3 g-COD person^{-1} day^{-1}, 3.4 g-TN person^{-1} day^{-1} and 0.31 g-TP person^{-1} day^{-1}, respectively.

3.2 Combined *jokaso,* Simple *Jokaso* and Night Soil Treatment Populations

BOD loads at the measurement points of the rivers and BOD emissions in the drainage areas are shown in Table 4. Column (2) of Table 4 indicates BOD loads of the drainage area simply calculated as the difference of BOD loads at the measurement points shown in column (1). Column (4) of Table 4 indicates total BOD emissions above the measurement points calculated from BOD emissions in each drainage area shown in column (3). Reaching ratios shown in column (5) of Table 5 are calculated with BOD loads at the measurement points, column (1) of Table 4, and total BOD loads above and in the drainage area, column (4) of Table 4. Reaching ratios shown in column (6) of Table 5 are calculated with BOD loads of the drainage area calculated form BOD loads at the measurement points and the upper measurement point(s), column (2) of Table 4, and total BOD loads in the drainage area, column (3) of Table 4.

BOD loads per capita flowing into pubic water bodies were calculated for combined and simple *jokaso* and night soil treatment populations were calculated as shown in Table 5. The BOD loads calculated from the reaching ratios based on the total BOD loads and total BOD emissions above and in the drainage area(s), which are shown in columns (8)-(10) of Table 5, are calculated as from 0.8 to 2.3 (1.5, values in the parentheses are populations weighted average) g-BOD person^{-1} day^{-1} for combined *jokaso* population, 8.3 to 23 (15) g-BOD person^{-1} day^{-1} for simple *jokaso* population, and 7.8 to 21 (14) g-BOD person^{-1} day^{-1} for night soil treatment. The BOD loads per capita calculated from the reaching ratios based on the corresponding BOD loads and BOD emissions in the drainage area, which are shown in columns (11)-(13), are calculated as from 0.8 to 2.9 (2.1) g-BOD person^{-1} day^{-1} for combined *jokaso* population, 8.3 to 29 (19) g-BOD person^{-1} day^{-1} for simple *jokaso* population, and 7.8 to 27 (16) g-BOD person^{-1} day^{-1} for night soil treatment population. The BOD loads per capita considering the removal rates of riverside purification facilities and agriculture village wastewater treatment facilities, and percentages of geological area above and below the measurement points in the drainage area, which are shown in columns (14)-(16) of Table 5, are calculated as from 1.1 to 2.1 (1.4) g-BOD person^{-1} day^{-1} for combined *jokaso* population, 12 to 21 (13) g-BOD person^{-1} day^{-1} for simple *jokaso* population, and 11 to 20 (13) g-BOD person^{-1} day^{-1} for night soil treatment population. Populations weighted averages and standard deviations of pollutant loads per capita were shown in Table 5.

COD loads at the measurement points, COD loads corresponding to the drainage areas, COD emissions in the regions and COD emissions above the drainage area are summarized in Table 6.

Reaching ratios of COD loads are shown in column (5)-(7) of Table 6, of which calculation methods are the same as those of BOD loads shown in Table 5. COD loads per capita flowing into public water bodies are summarized in Table 7. The COD loads per capita flowing into public water bodies calculated from total COD loads in the river and total COD emissions above the drainage area, shown in columns (8)-(10) of Table 7, are from 0.8 to 3.6 (1.7) g-COD person^{-1} day^{-1} for combined *jokaso* population, 3.0 to 13 (6.1) g-COD person^{-1} day^{-1} for simple *jokaso* population, and 3.5 to 11 (5.8) g-COD person^{-1} day^{-1} for night soil treatment population. The COD loads per capita calculated from corresponding COD loads of each drainage area and COD emissions in each drainage area, shown in columns (11)-(13) of Table 7, are from 0.9 to 3.6 (1.2) g-COD person^{-1} day^{-1} for combined *jokaso* population, 3.2 to 13 (4.0) g-COD person^{-1} day^{-1} for simple *jokaso* population, and 3.5 to 11 (4.3) g-COD person^{-1} day^{-1} for night soil treatment population. COD loads per capita considering the removal ratios of the riverside purification facilities and the agriculture village wastewater treatment facilities, shown in columns (14)-(16), are from 1.3 to 4.0 (3.0) g-COD person^{-1} day^{-1} for combined *jokaso* population, 4.1 to 14 (9.6) g-COD person^{-1} day^{-1} for simple *jokaso* population, and 4.3 to 11 (7.4)

Table 8 A format of environmental house accounting (EAH) books of domestic wastewater treatment: Simple *jokaso* population, prepared based on population average of pollutant loads per capita flowing into the public water body in Chiba City.

Simple *jokaso*	PL ratio[1)]	Pollutant loads flowing into pubic water body[2)]		Today's decrease		Decrease in this month		Estimation for calcualtion
		BOD	COD	BOD	COD	BOD	COD	
	%	mg	mg	mg	mg	g	g	
Nightsoil	30	3990	2880					
Bath	20	2660	1920	800	0	24.0	17.4	
Decrease shampoo and soap		800	580	800	580	24.0	17.4	The decrease effect to be 30%
Kitchen	40	5320	3840	370	810	11.1	24.3	
No use of detergent		830	0					The previous used amount to be 5ml $person^{-1}$ day^{-1} (2g-BOD and COD $person^{-1}$ day^{-1})
Decrease detergent		415	0					Decrease to half
Do not drain rice washing water		830	10					Pollutant loads of rice washing water to be 2g-BOD and COD $person^{-1}$ day^{-1})
Use paper filter for kitchen		370	810	370	810	11.1	24.3	The removal rate to be 7% (BOD, COD)
Use net for kitchen		160	580					The removal rate to be 3% (BOD, COD)
Treatment during and after cooking		2660	1920					The removal rate to be 50%
Do not drain residual liquid								
Dressing 5ml		1360	27					
Chinese noodle soup 50ml		540	11					
Used edible oil 10ml		6900	138					
Washing clothes	10	1330	960					
Decrease detergent		540	0					The decrease to be 5g $person^{-1}$ day^{-1} (1.3g-BOD and COD $person^{-1}$ day^{-1})
Total of pollutant load per capita	100	13300	9600	12130	8790	364	246	
Decrese of pollutant load per capita	—	—	—	1170	810	35	42	
Decrese of pollutant load for a family of four	—	—	—	—	—	140	167	

Note: 1) Source of pollutant loads (PL) ratios is Ministry of Environment (2002); 2) Public water body is supposed to the measurement points of the drainage area, and pollutant loads per capita are supposed to be the population weighted average.

Table 9 Pollutant loads per capita by domestic wastewater treatment methods, which are compared with those running into Sanbanze tidal coastal zone, Tokyo Bay, and those at the mouth of Ebigawa River. (Tsuzuki and Ogawa, 2004; Tsuzuki, 2004b)

Pollutant loads	Pollutants	COD	T-N	T-P
Pollutant loads to Tokyo Bay (kg day^{-1}) [1]		247,000	254,000	21,100
Pollutant loads to Sanbanze tidal zone (kg day^{-1}) [2]		6,243	4,948	—
Pollutant loads at the river mouth of Ebigawa River (kg day^{-1}) [3]		951	797	88.5
Pollutant loads by domestic wastewater at the mouth of Ebigawa River (kg day^{-1}) [4]		770	642	71.4
Pollutant loads per capita runnning into the coastal zone (g person^{-1} day^{-1})[4]	Wastewater treatment plant	2.3	3.7	0.22
	Combined *jokaso*	1.5	3.6	0.39
	Simple *jokaso*	5.2	3.9	0.43
	Nightsoil treatment	5.1	4.3	0.41
	Combined *jokaso* + Riverside purification	0.3	2.5	0.28
	Simple *jokaso* + Riverside purification	1.0	2.7	0.30
	Nightsoil treatment + Riverside purification	1.8	4.1	0.37

References: 1)National Environmental Conference Water Department Gross Pollutant Loads Control Professional Committee (1999); 2)Chiba prefecture (1998); 3)Tsuzuki (2003); 4)Tsuzuki and Ogawa (2004) and Tsuzuki (2004b).

g-COD person^{-1} day^{-1} for night soil treatment population. Populations weighted averages and standard deviations of pollutant loads per capita were shown in Table 7.

3.3 Environmental Accounting Housekeeping (EAH) Books of Domestic Wastewater

A format of EAH books of domestic wastewater was prepared for simple *jokaso* populations, and drainage areas in Chiba City (Table 8) as an example. The BOD and COD loads per capita flowing into the public water bodies in Table 8 are populations weighted averages. In Table 8, the initial pollutant loads per capita before pollution reduction activities are supposed to be populations weighted average of simple *jokaso* population in the drainage area. BOD loads per capita flowing into public water body, 13,300 mg-BOD person^{-1} day^{-1}, was divided into four kinds of household activities: 3,990 mg person^{-1} day^{-1} from night soil, 2,660 mg person^{-1} day^{-1} from bath, 5,320 mg person^{-1} day^{-1} from kitchen and 1,330 mg day^{-1} person^{-1} from washing clothes. When the person decreases the amount of shampoo and soap in the bath, decreased amount of BOD load is supposed to be 800 mg-BOD person^{-1} day^{-1}. Pollutant loads decrease in a month would be 24 g person^{-1} month^{-1}. In the same way, when the person use paper filter for kitchen, decreased amount of pollutant loads are calculated to be 370 mg-BOD person^{-1} day^{-1}, and 11g-BOD person^{-1} month^{-1}. The decreased pollutant loads in a month with the two measurements described above would be 35 g-BOD person^{-1} month^{-1}. The decrease amounts would be four times for the family of four, 140 g-BOD month^{-1}. COD loads reduction calculation is the same procedures with BOD loads reduction calculation.

4. DISCUSSION

The pollutant loads per capita flowing into public water body by wastewater treatment methods were calculated for drainage areas in Chiba City, Chiba Prefecure (Table 3, 5 and 7). The pollutant loads per capita were found to be different by the drainage area even the domestic wastewater treatment method is the same as Tsuzuki (2004b) pointed out as an important point of EAH books. Pollutant loads per capita flowing into public waterbody have been proposed more friendly indexes to ordinary citizens (Tsuzuki and Ogawa, 2004; Tsuzuki, 2004b).

Of the three methods used in this paper, the third calculation is sonsidered to be more precise than other two methods because of the applied calculation methods. The ratios of standard deviations and means are form 0.29 to 0.39 for BOD loads per capita, and 0.34 to 0.73 for COD loads per capita. Variation of COD loads per capita was found to be larger than thar of BOD.

The reaching ratios less than zero were in the lower drainage areas of the rivers. Flow rates of rivers are affected by tide near the river mouth, and flow rates and, therefore, pollutant loads were considered as underestimated. The reasons of the reaching ratios lager than a hundred percent were considered as larger daytime populations, some activities with pollutant emissios which were not considered in this study, or estimation errors of the pollutant emissions or pollutant loads in the river.

Tsuzuki (2004b) calculated pollutant loads per capita in Ebigawa River drainage area (Table 9).

Table 10 A format of environmental house accounting (EAH) books of domestic wastewater treatment: Simple *jokaso* population, Ebigawa River drainage area. (Tsuzuki and Ogawa, 2004; Tsuzuki, 2004b)

Simple *jokaso*	PL ratio[1)]	Pollutant looads flowing into coastal zone			Today's decrease			Decrease in this month			Estimation for calcualtion
		COD	T-N	T-P	COD	T-N	T-P	COD	T-N	T-P	
	%	mg	mg	mg	mg	mg	mg	g	g	g	
Nightsoil	30	1560	1170	130							
Bath	20	1040	780	90	310	0	0	9.4	0	0	
Decrease shampoo and soap		310	0	0	310	0	0	9.4	0	0	The decrease effect to be 30%
Kitchen	40	2080	1560	170	150	330	10	4.5	9.9	0.3	
No use of detergent		450	0	0							The previous used amount to be 5ml person^{-1} day^{-1} (2g-COD person^{-1} day^{-1})
Decrease detergent		225	0	0							Decrease to half
Do not drain rice washing water		450	10	1							Pollutant loads of rice washing water to be 2g-COD person^{-1} day^{-1}, 24mg-TN person^{-1} day^{-1} and 2mg-TP person^{-1} day^{-1}
Use paper filter for kitchen		150	330	10	150	330	10	4.5	9.9	0.3	The removal rate to be 7(COD), 21(T-N), 4(T-P) %
Use net for kitchen		60	230	3							The removal rate to be 3(COD), 15(T-N), 2(T-P) %
Treatment during and after cooking		1040	780	86							The removal rate to be 50%
Do not drain residual liquid											
Dressing 5ml		750	15	8							
Chinese noodle soup 50ml		290	6	3							
Used edible oil 10ml		3800	76	0							
Washing clothes	10	520	390	43							
Decrease detergent		290	0	0							The decrease to be 5g person^{-1} day^{-1} (1.3g-COD person^{-1} day^{-1})
Total of pollutant load per capita	100	5200	3900	430	4740	3570	420	142	107	12.6	
Decrese of pollutant load per capita	—	—	—	—	460	330	10	14	10	0.3	
Decrese of pollutant load for a family of four	—	—	—	—	—	—	—	55	40	1.2	

Note: 1) Source of pollutant loads (PL) ratio is Ministry of Environment (2002)

The Ebigawa River drainage area is west of Chiba City, and Ebigawa River is flowing into Sanbanze tidal coastal zone, which is only a tidal coastal zone left in Tokyo Bay after the development with land fillings. Municipal and administrative efforts to preserve and reclaim the tidal coastal zones have been held including a series of the Sanbanze Reclamation Plan Investigation Conference, Sanbanze Roundtable Conference, which has been organized by Chiba Prefecture since April 2003 (Chiba Prefecture, 2004). The Ebigawa River drainage area is 26 km^2, population in the drainage area was calculated as 220 thousands persons, and population density was 8,460 persons $km^{2\ -1}$. COD and nitrogen loads per capita for WTP populations in Chiba City were almost the same as those in Ebigawa River drainage area, however, phosphorus pollutant loads per capita in this study was larger by about 40% than that in Ebigawa River drainage area. The reason of the differences is phosphorus removal rate in WTP. Pollutant loads per capita flowing into public waterbody can include the effects of water purification facilities as shown in Table 9. Pollutant loads per capita flowing into the coastal zone were calculated based on the pollutant loads at the river mouth of Ebigawa River. The pollutant loads are considered to be affected by tidal and could be underestimated. So, the pollutant loads per capita shown in Table 9 could be underestimated.

The pollutant loads per capita flowing into public water bodies in Table 5 and 7 do not take effects of the riverside purification facilities and agriculture village wastewater treatment facilities into consideration. The pollutant loads of populations with these treatments would be smaller than the values shown in the Tables.

Tsuzuki (2004a) calculated pollutant loads per capita flowing into coastal zones and lakes along the developing countries. Calculated pollutant loads per capita flowing into coastal zone were calculated 0.1-45 kg-BOD $person^{-1}$ yr^{-1}, 0.1-4.6 kg-TN $person^{-1}$ yr^{-1}, and 0.01-1.9 kg-TP $person^{-1}$ yr^{-1}. Most of the pollutant loads per capita flowing into coastal zones and lakes were found to be almost the same with or larger than those in Japan, Ebigawa River drainage area and the drainage areas in Chiba City.

The pollutant loads at the measurement points were based on administrative data, annual means of pollutant concentration and flow rate. Urban runoff pollution analysis has been developed to calculate total pollutant loads in the rivers, streams and sewage pipes. Pollutant loads per capita flowing into pubilc waters can be calculated more precisely with these kinds of analysis and methods.

United States Environmental Protection Agency (EPA) has introduced Combined Sewer Overflow (CSO) Control Policy in 1994 and the policy establishes a consistent national approach for controlling discharges from CSOs to the public waters through the National Pollutant Discharge Elimination System (NPDES) permit program (EPA, 1994, 2004). In Japan, Ministry of National Land and Transportation has established dedicated committee to discuss on and summarize the improvement measurements of combined WTP including CSO problems (Okamoto, 2002). In european countires, the same kinds of CSO pollutant loads reduction measurements have been developed including urban water pollutant loads policy manual of 1998 in England, design standards of wastewater treatment plants (ATV-A128) of 1977 in Germany, and regulations on the procedures of emission permissions of 1993 in France (Okamoto, 2002).

Table 10 shows an example of the EAH books for simple *jokaso* population in Ebigawa River drainage area (Tsuzuki and Ogawa, 2004; Tsuzuki, 2004b). EAH books for other pollutant can be prepared if data on the pollutant emission and the pollutant load in the river is available.

EAH books of domestic wastewater would be effective tools for enlightenment, dissemination and environmental education, because only some basic administrative information and environmental data are necessary for their calculation and preparation. Interests with lives, materials and water quality would increase through the EAH books of domestic wastewater and it would be effective for environmental and scientific education.

5. Conclusions

A format of EAH books of domestic wastewater was prepared for the drainage areas in Chiba City. Pollutant loads per capita flowing into public waterbody were calculated for the purpose of making use of it for preparation of EAH books.

It was found that pollutant loads per capita flowing into public waterbody were different between the drainage regions, and variations of COD loads per capita were found to be larger than those of BOD. BOD loads per capita flowing into public waterbody were calculated as 0.83 g-BOD $person^{-1}$ day^{-1} for WTP populations, 0.8-2.4 g-BOD $person^{-1}$ day^{-1} for combined *jokaso* populations, 8.3-24 g-BOD $person^{-1}$ day^{-1} for simple *jokaso* populations, and 7.8-21 g-BOD person^{-1} day^{-1} for night soil treatment populations. COD loads per capita flowing into public waterbody were calculated as 2.3 g-COD person^{-1} day^{-1} for WTP populations, 0.8-4.0 g-COD person^{-1} day^{-1} for combined *jokaso* populations, 3.2-13 g-COD person^{-1} day^{-1} for simple *jokaso* populations, and 3.4-12 g-COD person^{-1} day^{-1} for night soil treatment populations. The effect of riverside water purification facilities and agriculture village wastewater treatment facilities are not included the pollutant loads per capita for combined and simple *jokaso* populations and night soil treatment facilities.

A format of EAH books of domestic wastewater was prepared for simple *jokaso* populations in the drainage area of Chiba City with populations weighted average pollutant loads per capita flowing into public waterbody. The EAH books should be prepared for each drainage area and domestic wastewater treatment method.

Pollutant loads per capita by domestic wastewater treatment methods and drainage area, and EAH books of domestic wastewater have been proposed as essential indexes and effective tools in the field of water environment education and dissemination.

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