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A Life Model Planning necessary for the calculation of the environmental impact at the application of Sanitary wares

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KEY WORDS : Life cycle analysis, Water and energy consumption, Life style model, Calculate, Daily use

ABSTRACT

This paper discusses the result of questionnaires on how the equipment necessary for the development of the sanitary wares called eco-designed commodities such as toilet, washing-stand, bathroom and kitchen are used. Time and frequency of use on weekdays and weekends are researched according to the following unit periods ①06:00-10:00 ②10:00-16:00 ③16:00-20:00 ④20:00-24:00 ⑤24:00-06:00. A frequency to the toilet on weekends at ② and ③ periods was confirmed 20～30% more than that on weekdays. The estimated consumption of water from the questionnaire was agreed with published values except for the washing-stand and the kitchen, and it showed about 25% more than the result of INAX's environmental household-accounting. The eco-designed commodities used for toilet, bathroom and washing-stand in terms of CO_2 emission and the consumption of water and electricity lead by the result of this study's life model are compared with actual ones.

KEY WORDS : Life cycle analysis, Water and energy consumption, Life style model, Calculate, Daily use

INTRODUCTION

Since sanitary wares have relatively long life such as more than 10 years, they are obliged to high impact in use throughout their life stages(Premanufacturing, Manufacturing, Transporting, Construction, Use and Recycling or Disposal). According to the research of Society of Heating, Air-conditioning and Sanitary Engineers of Japan, when an actual toilet is manufactured, it produces 39.09(Kg-CO_2), which is merely 4% of the impact in use. Reduction of the impact in use(water and electricity) is a serious problem, however, an ideal life model necessary for eco-design hasn't been established. This paper aims at making the prototype of sanitary wares in a household.

EXPERIMENTAL PROCEDURE

Method of Research(Area, Content of the Questionnaire, Property of sample)

In order to clear the water consumption of a household, Kanto area covering Tokyo, Kanagawa, Chiba and Saitama prefectures are selected for the questionnaire whose water consumption is relatively high nationwide.[1] To confirm the reliability of the result on the questionnaire, the INAX's environmental household-accounting conducted at Chita area in Aichi prefecture was referred.

The period for the questionnaire was one week including weekends form October 16th to 27th, 1995. In regard to the environmental household-accounting, the average value of July and August(two months) in 1997 was used. The questionnaire shown in Table 1 was conducted to fifty one households; 253 people, the average family members are 4.86/household, and the environmental household-accounting was carried out for 200 households; the average family members are 3.70/household. The unit period is divided up into ①06:00-10:00 ②10:00-16:00 ③16:00-20:00 ④20:00-24:00 ⑤24:00-06:00. Those households having two toilets and washing-stands were requested to notify the frequency and time use of the toilet 1,2 and the washing-stand 1,2 respectively.

Table 1 Heads of the Questionnaire

Sample Profile	Number of family Age of family members
Toilet	Frequency of use / unit period
Washing-stand	Time of use/unit period
Kitchen	Time of use/unit period
Bathing	Starting time of bathing Time use Showering time

Values used for the calculation of water consumption

The amount of water to fill a bathtub is estimated by Hosoi et. al.[2] from the shipped numbers of bathtubs ; 38 liters/person/day, and 21.6 liters/person/day by Kiya et. al. [3] for a house cleaning and a car washing were used.

Table 2 Constituent Ages for Samples

Age	(year old)	0～2	3～6	7～12	13～20	21～30	31～40	41～50	over51
Targeted number of people	(person)	10	31	50	21	4	65	34	38

The amount of water filled in a bathtub was decided by 60% of its full capacity. The amount of water to flush a toilet was determined to 10 liters for a big flush and 8 liters for a small flush.[2)3)]

The optimum water flow for the washing-stand, the kitchen and the bathroom is determined by 5.5, 5.0 and 8.5 liters/min.[4)] If there were two toilets and washing-stands in a household, the amount of water use was summed up.

The weighted average of the above mentioned figures was calculated by the ratio of 5 for weekdays and 2 for weekends, and this was determined as the consumption of water per day and per person. Referring to the published values with the result of calculation, the overall consumption was estimated, and it was compared with the result of energy consumption of INAX's environmental household-accounting.

The EASY-LCA of Toshiba Engineering Corp. was used for calculations of the environmental impact ,and the life of sanitary wares were determined by 20 years.[5)]

Frequency of use of sanitary ware per unit period Number of visit to the toilet

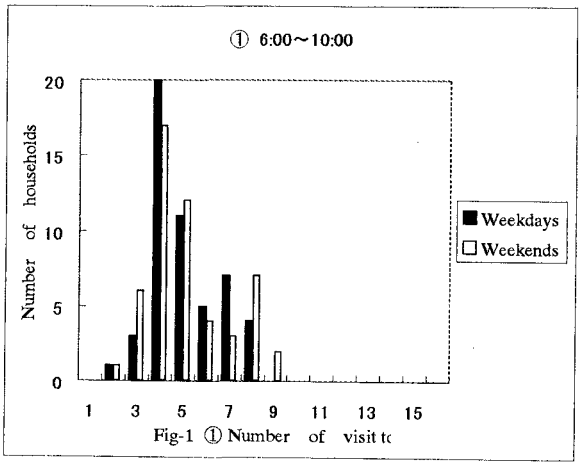

Fig-1 ① Number of visit to

Number of visit to the toilet per unit period is shown in Fig. 1 ① and ②. The periods ① 06:00-10:00, ④ 20:00-24:00 and ⑤ 24:00-06:00 show almost the same figure on both weekdays and weekends. The period ② 10:00-16:00 on weekends shows 1.3 times more than that of weekdays, and the period ③ 16:00-20:00 shows 25% more than that of weekdays.(Refer to Table 3) The

Table 3 Number of visit to the toilet

		period(times/household)					
		~10:00	10:00~16:00	16:00~20:00	20:00~24:00	24:00~	Total
Weekdays	Toilet 1	3.51	2.71	4.24	3.37	0.47	14.29
	Toilet 2	1.53	0.41	0.73	1.27	0.27	4.22
	Total	5.04	3.12	4.96	4.65	0.75	18.51
Weekends	Toilet 1	3.73	6.04	5.14	3.53	0.51	18.94
	Toilet 2	1.43	1.27	1.08	1.27	0.33	5.39
	Total	5.16	7.31	6.22	4.8	0.84	24.33

periods ① and ④ show nearly the normal distribution, but there are some distorted values at other periods. Since the period ② shows two peaks on weekdays, a 50% cumulative value is used representing the model calculation.

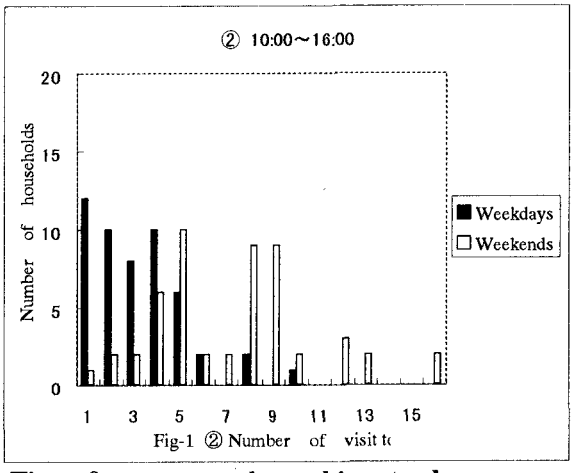

Fig-1 ② Number of visit to

Time of water use at the washing-stand

Time of water use at the washing-stand per unit period doesn't show any difference between weekdays and weekends. Table 4 shows the time of the 50% cumulative value. The period ① 06:00-10:00 shows the longest time of use at the washing-stand in a day(15 minutes on weekdays and 13 minutes on weekends) which represents about 40~45% of the total time of use(weekdays:32 minutes, weekends:34 minutes). If the time of use at the period of ④ 20:00-24:00(weekdays:9.2 minutes, weekends:9.4 minutes) is added to the one of the period ①, the total time of water use reaches nearly to 70%.

Table 4 Using-time at the washing-stand

		period(minute/household)					
		~10:00	10:00~16:00	16:00~20:00	20:00~24:00	24:00~	Total
Weekdays	Washing-Stand 1	12.25	2.51	4.00	7.53	0.53	26.82
	Washing-Stand 2	2.53	0.25	0.29	1.65	0.71	5.43
	Total	14.78	2.76	4.29	9.18	1.24	32.25
Weekends	Washing-Stand 1	10.98	4.59	4.47	7.90	0.31	28.25
	Washing-Stand 2	2.29	0.65	0.33	1.45	0.71	5.43
	Total	13.27	5.24	4.80	9.35	1.02	33.68

Time of water use at the kitchen

Time of water use at the kitchen doesn't show any difference between weekdays and weekends. Table 5 shows the 50% cumulative value. The period ③ 16:00-20:00 shows the longest time of use (weekdays:31.41 minutes, weekends:33 minutes) and it represents about 40% of the total time of use(weekdays:85 minutes, weekends:86 minutes). The time of use in other periods ① 06:00-10:00 ② 10:00-16:00 and ④ 20:00-24:00 represents 25~15% respectively.

Table 5 Using-time at the kichen

	period(minute/household)					
	~10:00	10:00~16:00	16:00~20:00	20:00~24:00	24:00~	Total
Weekdays	22.96	16.65	31.41	14.06	0.29	85.37
Weekends	20.12	20.61	32.88	12.51	0.20	86.31

Amount of water used at the bath (bathing time and showering time)

Fig. 2 shows the bathing time of a husband. Each constituent group can be divided into two ; a group less than 20 minutes of bathing time and a group more than 30

minutes of bating time. No distinctive difference between weekdays and weekends is observed. Table 6 shows the

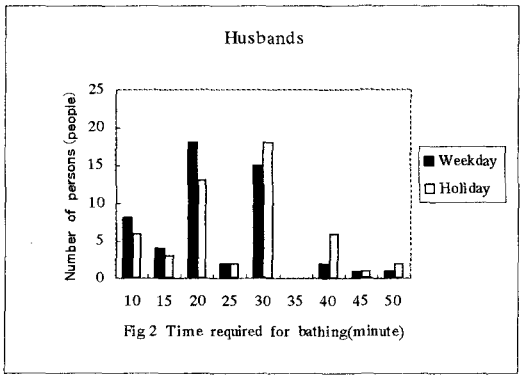

Fig 2 Time required for bathing(minute)

50% cumulative value and shows that each group falls into within the range of 20～30 minutes. Bathing time is

Table 6 Bathing time (minute/person)

	Wife	Husband	Child 1	Child 2	Child 3	Father	Mother	Others
Weekdays	25.59	22.94	23.53	20.29	20.50	24.29	23.78	21.67
Weekends	27.84	26.57	25.29	20.98	21.80	25.00	24.41	26.67

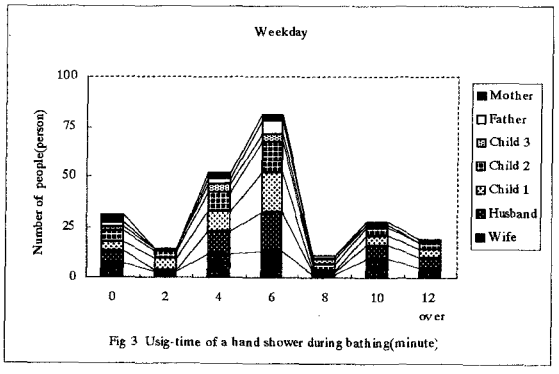

Fig 3 Usig-time of a hand shower during bathing(minute)

determined from 17:00 to 24:00. The showering time on weekdays and weekends are the same. According to Fig. 3, the maximum showering time in each group is 4～6 minutes respectively. Table 7 shows the 50% cumulative value of Fig 3.

Water consumption estimated from the frequency and the time use

Comparison among the estimated water consumption from the frequency and the time use, Reference and the

Table 7 Showering time (minute/person)

	Wifes	Husbands	Child 1	Child 2	Child 3	Father	Mother	Others
Weekdays	5.96	5.96	5.57	5.14	4.21	4.14	5.00	6.67
Weekends	6.18	6.14	5.85	5.25	4.40	4.21	4.86	6.67

Environmental household-accounting

In regards to the toilet and the bathroom, the result is agreed well with the reference, however, the washing-stand and the kitchen show relatively big figures. This is considered due to a different way of using water and plumbing fixtures installed. The total water consumption per day per person of the models shown in Table 8 together with the water for house cleaning and the car washing becomes 315 liters. When this was compared with the result of the INAX's environmental household-accounting(270 liters/day/person), the water consumption was 16% more than that accounting .

Working model for the equipment of sanitary wares and its application

Table 8 Comparison of the water consumption calculated from the result of the questionnaire and other (liters/person/day)

Sampling method	This study	Kiya et al 3)	Hosoi et al 2)	Motoki et al 6)
Data base	51 households	Reference	Reference	29 households
Method	Questionnaire	Statistical method	Regression	Measurement
Laundry	(35)	36～72	35	58
Toilet	36.2	38～47	40	57.5
Washing-stand	36.7	9～32		12.5
Kitchen	88	40～65	50	40.5
Bathing(out of tub)	51	38～65	100	69.8
(inside of tub)	(40)		40	
Others	(22)	20～23		

Table 9 Using models with sanitary wares

Utility	Unit	Frequency of use/equipment/unit period				
		～10:00	10:00～16:00	16:00～20:00	20:00～24:00	24:00～
Toilet	times	5.1	4.3	5.3	4.7	0.8
Washing-stand	minute	14.3	3.5	4.4	9.2	1.2
Kitchen	minute	22.1	17.8	31.8	13.6	0.3
Bathing	minute			50.0	50.0	
Showering	minute			12.0	12.0	

A model planning based on the questionnaire is shown in Table 9 and the comparison of the environmental impact using the model is shown in Table 10.

The eco-designed toilet could reduce 2 litters of flush water with keeping soil-proof and maintenance-performance ability resulting in 25% of CO_2 emission was reduced.

The 15W fluorescent light and 60W incandescent light have the similar illuminant. By the use of 15W incandescent light on the bathroom and washing-stand ,could reduce 75% of CO_2 emission.

Table 10 Comparison of the CO2 emission eco-designed commodity and actual one.

Utility		Target	Specification	Consumption	Unit	kg-CO2
Toilet	Actual	Water	Big flush : 10L Small flush : 8L	1,179,720	L	577
	Ecodesign		Big flush: 8L Small flush : 6L	884,792	L	433
Washing-stand	Actual	Light	Incandescent lamp(60W×2)	216,080	Wh	92,423
	EcoDesign		Fluorescent lamp(15W×2)	54,020	Wh	23,106
Bathroom	Actual	Light	Incandescent lamp(60W×2)	729,270	Wh	311,927
	Ecodesign		Fluorescent lamp(15W×2)	182,317	Wh	77,982

SUMMARY

From the result of the questionnaire on the equipment of sanitary wares, the time use and frequency per unit period of the toilet, the washing-stand and the kitchen became clear. The useful model for the eco-designed commodities are sure to be established.

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