Analysis of the effect of the Containers and Packaging Recycling Law on the waste management practice in Nagoya city

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Abstract

Japan legislated the Containers and Packaging Recycling Law in 1995; the law was put into effect gradually and became effective totally in 2000. In this law, each municipality can choose how many items they collect for recycling, so that not all the municipalities in Japan collect all containers and packaging still now. In particular, big cities whose populations are more than 1 million can not collect all items, because the cost for recycling all items is too much and they do not have appropriate recycling routes.

This study examines the effect on the reduction of the amount of waste and on the environmental effects by the method of Material Flow Analysis and Life Cycle Assessment, through Nagoya city practices. Nagoya city has a population of more than 2 million. In the city, the law has been in force since 2000. Nagoya city is only one big city that collects all items of containers and packaging in Japan. So it is important to study Nagoya practice to evaluate the success of the law. Accordingly, the surveys of material flow and discharge amount of CO_2 and NOx were made in the years 1998 and 2001, then each year's data was compared.

By the study, it is observed that the amount of municipal waste discharge reduced by more than 266,000 ton and the amount of landfill reduced to almost half after enforcement of the law. On the other hand, the amount of collected containers and packaging gained 63,002 ton, and it multiplied about 3 times. Considering the environmental impact from the waste management system of Nagoya city including containers and packaging recycling, the amount of total discharge of CO_2 and NOx reduced by more than 34%. Therefore, the effects on the environment obviously improved. The law has accelerated the separating of containers and packaging from the waste going to landfill, and it not only has reduced the amount of waste but also has changed the contents of waste going for incinerating, causing more reduction of landfill. As a result, it clearly shows that the recycling based on the law has succeeded in reducing both the amount of waste going to landfill sites and the environmental effects.

Keywords: the Containers and Packaging Recycling Law, material flow analysis, life cycle assessment.

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1 Introduction

In Japan, it is said that more than 50 million ton municipal waste like organic waste from families, is discharged a year, and landfill sites are filling rapidly. In this situation, Japan legislated the containers and packaging recycling law in 1995, because containers and packaging, like cans, bottles and other containers occupy more than 62% of volume, 24% of weight of municipal waste. The law was put into effect gradually (starting from Glass bottles and PET bottles in 1997, to all paper packaging and plastic packaging in 2000) and became effective totally in 2000. In this law, each municipality can choose how many items they collect for recycling, and not all municipalities of Japan collect all containers and packaging still now. Because municipalities have to pay to collect sorted containers and packaging and the expense is usually much for them. Figure 1 shows the system of the law.

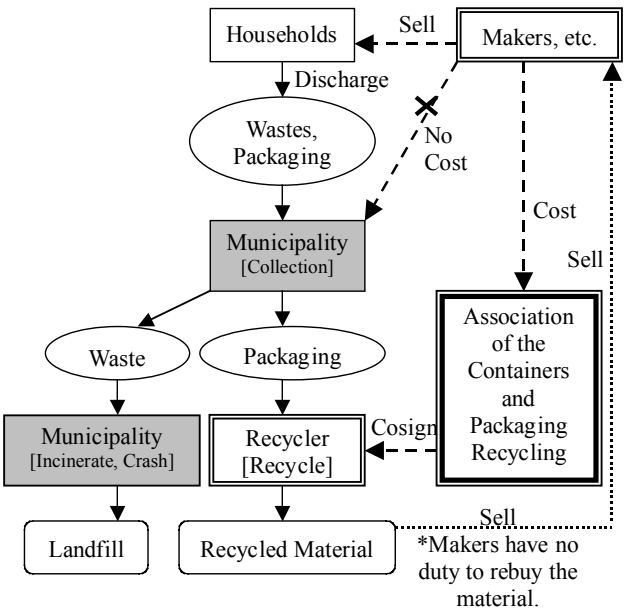

Figure 1: System of the Containers and Packaging Recycling Law of Japan [1].

Nagoya city, is the only big city that collects all items of containers and packaging; it started to enforce the law in August 2000. Because the city gave up making a new landfill site and had a landfill crisis, it had to reduce the amount of waste going to landfill site urgently.

The purpose of this study is to examines the effect of the law on the change of discharge, reduction of landfill and on the environmental impacts by the method of material flow analysis and life cycle assessment, through Nagoya city practice. Also it is important to study Nagoya practice for evaluating the law.

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2 Method of analysis

All surveys are done for the year 1998 and 2001. Surveyed items are steel cans, aluminium cans, glass bottles, PET bottles, paper cartons, other paper wrappings and packaging and other plastic wrappings and packaging, also total municipality waste. However, the result of material flow analysis is to total all the items.

2.1 Material flow analysis (MFA)

Material flow analysis is the method to understand the quantities and material balance of input and output through a system [2]. This study surveys the flow from discharge to recycling for containers and packaging, and the flow from discharge to landfill for municipal waste including the containers and packaging. The survey was carried out attending meetings at Nagoya city office and relative recycling corporations.

Figure 2 is a model of waste management flow of Nagoya city.

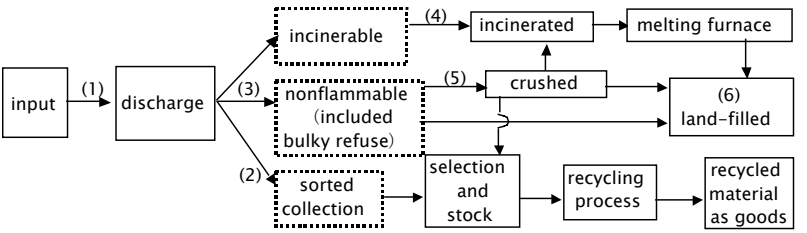

Figure 2: Waste Management Model of Nagoya city.

We have estimated Nagoya city's amount of containers and packaging from the data collected about National containers and packaging. We have estimated that the input of containers and packaging equals the amount of discharge (1). The amount of sorted collection is actual result (2). The amount of containers and packaging included in municipal waste is investigated from the Nagoya City Waste Detailed Contents Survey [3](3). Containers and packaging included in incinerable waste are burned then land filled. Plastic has no ash (4). Nonflammable waste is crushed out for landfill, or directly land filled without crush. The crushed rate that means the amount of crushed non-flammable waste divided by all non-flammable wastes, is 45.8% in 1998 and 72.0% in 2001. Crushed steel cans and aluminium cans are collected as recycle material (5). The sum total of ash, glass bottles that included crushed waste and waste without crush is the amount of landfill (6).

2.2 Life Cycle Assessment (LCA)

LCA is the method to assess the impact on the environment from goods and service production to landfill or recycling (ISO14040). Usually, the amount of discharge of CO_2, NOx and so on within products lifecycle is evaluated

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environmentally. In this study, CO_2 and NOx are been examined for their effect on the environment (as gas).

This study is not really LCA because it is a comparison between the condition of 1998 and 2001, these two years waste managements do not have the same functions. And this study ignores the process from production to discharge as waste because it is regarded that the upper stream of products lifecycle is not changed so much between two years.

Nagoya city and relative corporations were surveyed as to the amount of electricity, gas, other fuels and products used and their effect on the amount of CO_2, NOx discharged in the waste management and recycling processes.

3 Results

3.1 MFA

Flows of total municipal waste are shown table 1, table 2, and flows of total containers and packaging are shown table 3 and table 4.

Table 1: Flow of municipal waste of Nagoya city in 1998 (ton).

		Recovery	Crushed	Incinerated	Landfill	sub-total
Imput to Nagoya city						
Discharge						1,173,702
	Incinerable			819,519	140,615	820,572
	Nonflammable	9,959	95,587	63,639	139,189	211,733
	Sorted Collection	141,397				141,397
sub-total		151,356	95,587	883,158	279,804	1,173,702

Table 2: Flow of municipal waste of Nagoya city in 2001 (ton).

		Recovery	Crushed	Incinerated	Landfill	sub-total
Imput to Nagoya city						
Discharge						1,104,248
	Incinerable			647,294	91,516	647,570
	Nonflammable	6,218	84,756	69,044	43,323	118,309
	Sorted Collection	338,369				338,369
sub-total		344,587	84,756	716,338	134,839	1,104,248

Table 3: Flow of total containers and packaging of Nagoya city in 1998 (ton).

		Recovery	Crushed	Incinerated	Landfill	sub-total
Input to Nagoya city						165,756
Discharge						166,360
	Incinerable			87,780	5,232	87,780
	Nonflammable	7,388	26,218	9,992	39,930	57,310
	Sorted Collection	21,270				21,270
sub-total		28,658	26,218	97,772	45,161	166,360

Table 4: Flow of total containers and packaging of Nagoya city in 2001 (ton).

		Recovery	Crushed	Incinerated	Landfill	sub-total
Input to Nagoya city						163,299
Discharge						164,194
	Incinerable			50,990	2,994	50,990
	Nonflammable	4,174	18,526	12,052	9,492	25,718
	Sorted Collection	87,486				87,486
sub-total		91,660	18,526	63,575	12,482	164,194

3.1.1 Amount of discharge of containers and packaging

Each items discharge as disposal waste or sorted materials for recycle are shown in figure 3 and figure 4.

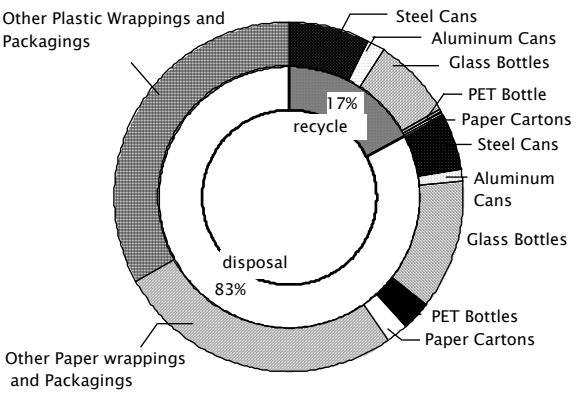

Figure 3: Ratio of disposal/recycle of various refuse in 1998.

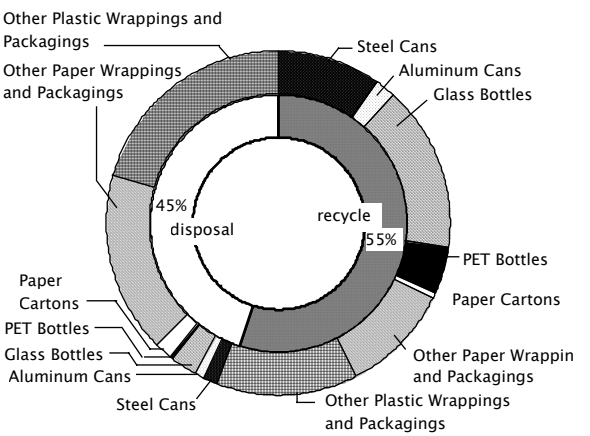

Figure 4: Ratio of disposal/recycle of various refuse in 2001.

In these figures, disposal containers and packaging ware 83% of all discharged containers in 1998, and it becomes 45% in 2001, the amount of recycled containers becomes more than the disposal after enforcement of the law. The amount of sorted collection increases 63,002 ton, it multiplied about 3 times. However, still more than 75 thousand ton containers was disposed.

To focus on each items in detail, other paper wrappings and other plastic wrappings occupy 83.6% of all disposal containers and packaging. Because these two items are new collection for Nagoya citizen, and their amount of discharge is very huge compared with other items. Also, offices (not households) have no obligation to sort and separate these two items.

About PET bottles, the amount of discharge increase remarkably, also recycle is accelerated, recycle ratio (sorted/discharge) of Nagoya city is 91.0% in 2001. On the other hand, the amount of glass bottles discharge decrease 8.8%, and recycle ratio is 86.8% in 2001. Recycle ratio of steel cans and aluminium cans are also 69.4% and 49.3% in 2001. Aluminium cans should be sorted before municipal collection because it is only item to trade profitably.

3.1.2 Change of flow by the law

Figure 5 shows material flow change from 1998 to 2001. Upper box is total municipal waste and lower box is total containers and packaging included in municipality waste. The number inside small box is margin between 1998 and 2001.

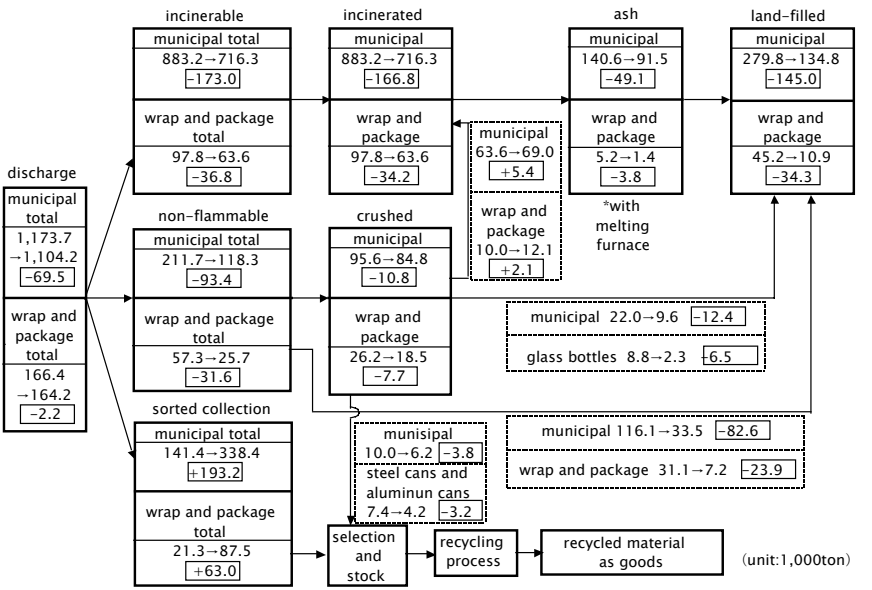

Figure 5: Flow of municipal waste/packaging with amount of reduction/increase from 1998 to 2001.

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Total discharge of containers and packaging occupies 14.2% of municipal waste in 1998, and occupies 14.9% in 2001 as weight. Amount of municipality disposal waste is 1.03 million ton in 1998, becomes 0.76 million ton in 2001, and reduces more than 266,000 ton (25.9%). Amount of containers and packaging that discharge to disposal is 0.14 million ton in 1998, becomes 0.08 million ton in 2001; this is 46.9% reduction, even the estimated amount of total input of containers and packaging to Nagoya city in 1998 and 2001 were almost same, this reduction contributes to 25.4% to reduce municipal waste.

Also, by reduction of nonflammable waste, the ratio to crush (middle management) becomes higher; seeing 2.1, reduction effect of crush becomes higher, too. Of course, nonflammable waste going to landfill site directly also reduces 71%. They are indirect waste reduction effects by containers and packaging recycle.

The amount of landfill reduces 0.15 million ton , becomes almost half after enforcement of the law, the reduction of packaging contributes 24.0%.

3.2 Environmental effect of the law

Table 5 shows the total amount of discharge of environmental effective material; in this study, CO_2 and NOx discharge from annual waste management of Nagoya city in 1998 and 2001. The processes from waste discharge to landfill or collected containers and packaging to recycling are understood based on the flow explained 3.1. Then, on the processes, the items within each process are examined to calculate the amount of discharge of CO_2 and NOx with standard emission factors, total amounts are given. In 1998, Nagoya city recycled less than in 2001, so the city should need new products more. This process is extra environmental effective emission in 1998. The recycled material and generating with incinerator cut down the emission of environmental effective material.

The processes and the items within each process and total amount are given.

*1: Environmental effect of collection of containers and packaging included in waste are divided by the ratio to occupy the inside volume of press-truck to collect and transport.

*2: Contribution to cut the environmental effect by the generation of electricity with incinerator is calculated as these units.

- Average plastic calory to burn is 8,300cal.
- Average other waste calory to burn is 1,900cal.
- CO_2 discharge with generating is 0.413kg-CO_2/kwh in 1998, 0.439kg-CO_2/kwh in 2001.

*3: Main environmental effect unit are refereed to LCA/LCI Investment of Japanese Ministry of Environment [4]. About environmental effects of substitute process, other paper wrappings are regarded as same as paper cartons, other plastic wrappings are regarded as same as PET bottles.

*4: Amount of recycled steel cans and aluminium cans are total of sorted collection and recycled material from middle management (crush) .

*5: Treated amount is total of municipal waste, sorted collection and amount of substitute process.

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Table 5: Environmental effect with waste management and the containers and packaging recycle of Nagoya city in1998 and 2001 (ton).

Process			Treated Amount(ton)		CO2(ton)		NOx (ton)	
			1998	2001	1998	2001	1998	2001
		Steel Cans	15032.0	5521.0	91.2	48.8	0.5	0.3
		Alumi. Cans	2755.0	2454.0	36.2	47.0	0.2	0.3
		Glass Bottles	20271.0	3911.0	30.3	8.5	0.2	0.1
		PET Bottles	4653.0	702.0	64.9	14.3	0.4	0.1
		Paper Cartons	2855.0	2601.0	10.4	13.8	0.1	0.1
		Other Paper Wrap & Pack	44619.0	27725.4	163.0	147.6	0.9	0.9
		Other Plastic Wrap & Pack	54905.0	33794.0	765.3	686.6	4.3	4.0
		Sub-Total	145090.0	76708.4	1161.3	966.6	6.5	5.7
	Crush,Relay		26218.0	18526.0	1236.5	903.4	1.0	0.5
	Incinerate (Total-Generate Merit) *2		97772.1	63041.8	76732.3	36231.7	109.0	42.6
		Incinerate Total	-	-	106287.6	51714.7	115.5	45.1
		Generate Merit	-	-	29555.3	15483.0	6.5	2.5
	Melting Furnace		-	195.2	-	91.5	-	0.0
	Land-fill		45409.6	16825.6	217.5	183.9	0.5	0.3
	Sub-Ttal① (Wrap & Pack in Waste)		145090.0	76708.4	79347.6	38377.0	116.9	49.1
	Collection		887216.0	689170.1	4597.7	5431.4	25.6	31.9
	Crach,Relay		69369.0	66230.4	3271.5	3229.6	2.6	1.9
	Incinerate (Total-Generate Merit) *2		785386.2	653295.7	186141.4	147496.9	264.4	173.4
		Incinerate Total	-	-	257838.4	210527.3	280.1	183.4
		Generate Merit	-	-	71697.0	63030.4	15.6	10.0
	Melting Furnace		-	11771.6	-	5515.5	-	2.0
	Land-fill		234394.8	118013.9	1122.5	1290.1	2.5	1.9
	Sub-Total② (organic waste, other)		887216.0	689170.1	195133.1	162963.6	295.1	211.1
Sub-Total①+②			1032306.0	765878.5	274480.7	201340.6	412.1	260.2
	Steel Cans		2339.3	-	1762.8	-	1.9	-
	Alumi. Cans		402.4	-	846.3	-	1.6	-
	Glass Bottles		9397.6	-	92.6	-	0.2	-
	PET Bottles		5040.0	-	3653.1	-	6.5	-
	Paper Cartons		252.0	-	94.0	-	0.1	-
	Other Paper Wrap & Pack		16308.0	-	6085.9	-	5.2	-
	Other Plastic Wrap & Pack		17904.0	-	12977.2	-	23.1	-
	Sub-Total③		51643.3	-	25511.9	-	38.5	-
	Steel	Collection	6171.1	12519.7	415.3	463.5	0.4	0.7
		Recycle Process*4	11687.0	13741.0	2828.6	3738.0	1.6	0.9
	alumi	Collection	1700.1	2384.7	247.6	191.0	0.3	0.3
		Recycle Process*4	2506.3	2908.7	728.5	857.2	1.0	0.4
	Glass	Collection	12317.0	25809.0	204.4	235.6	0.2	0.4
		Recycle Process	12067.8	21465.4	77.3	147.5	0.3	8.8
		Collection	604.0	7080.0	93.4	602.0	0.1	0.9
	PET	Recycle Process	534.0	5574.0	120.0	1478.3	0.1	0.2
	Carton	Collection	478.5	939.0	19.4	20.9	0.0	0.0
		Recycle Process	456.0	896.0	79.3	163.9	1.1	0.1
	Paper	Collection	-	16947.0	-	377.5	-	0.6
		Recycle Process	-	15894.0	-	10238.3	-	39.5
	Plastic	Collection	-	21806.0	-	1854.0	-	2.9
		Recycle Process	-	17904.0	-	7568.0	-	29.8
	Collection total		21270.7	87485.4	980.0	3744.5	1.0	5.9
	Recycle Total		27251.1	78383.1	3833.7	24191.3	4.1	79.7
	Recycle小 Sub-Total④ (Wrap,Pack)		21270.7	87485.4	4813.8	27935.8	5.1	85.6
	Steel Cans		11980.7	14320.0	9028.4	10791.3	9.5	11.3
	Alumi. Cans		2506.3	2908.7	5271.2	6117.5	9.9	11.5
	Glass Bottles		12067.8	21465.4	118.9	211.4	0.2	0.4
	PET Bottles		534.0	5574.0	387.1	4040.2	0.7	7.2
	Paper Cartons		217.5	433.5	81.2	161.8	0.1	0.1
	Other Paper Wrap & Pack		-	16308.0	-	6085.9	-	5.2
	Other Plastic Wrap & Pack		-	17904.0	-	12977.2	-	23.1
	Substitute Sub-Total⑤		27306.3	78913.6	14886.7	40385.2	20.4	58.9
Total (①+②+③+④-⑤) *5			1083949.3	765878.5	289919.7	188891.2	435.2	286.9

With the environmental impact from the waste management system of Nagoya city including containers and packaging recycling, the amount of total discharge of CO_2 and NOx was reduced more than 34%. Therefore, the effects on the environment obviously became better after the enforcement of the law.

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Particularly, as the amount of PET bottle and other plastic wrappings included in incinerated waste is reduced, the discharge of CO_2 and NOx reduced remarkably.

4 Conclusion

In the study of Nagoya city practices, the law has accelerated the separating of the containers and packaging form the waste going to landfill, and it not only has reduced the amount of waste but also has changed the contents of waste into a better type for incinerating, causing more reduction of landfill. Furthermore, the change of contents of waste, separating containers and packaging from the waste, reduces the groups of plastic in incinerated waste, so the amount of CO_2 and NOx discharged from incineration has clearly reduced. Especially, CO_2 is reduced more than 101 thousand ton after the enforcement of the law. As a result, it clearly shows that the recycling based on the law has succeeded in reducing both the amount of waste going to landfill sites and the negative environmental effects.

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