An Empirical Analysis of Industrial Waste Embodied in the 1995 Japanese Economy

By

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Abstract

This paper reports the level of waste generation (generation intensity) and landfill quantities (intensities) embodied in the 1995 Japanese economy. The present study applies the 1995 waste generation matrix and the 1995 landfill matrix (57 industrial wastes), constructed using industrial waste data collected by local governments, to the input-output analysis based on the non-competitive imports assumption. From the empirical results, we revealed not only sectoral differences in waste generation and in landfill quantities but also major economic forces driving these differences. The major findings are as follows. For the embodied landfill quantity, the top five sectors were construction, motor vehicles, wholesale trade & retail trade, medical service, health & hygiene and Water supply & sewage due to the remarkable use of waste-intensive activities and/or materials. The household consumption behavior led to about three times the amount of the household-oriented municipal wastes generated by direct household disposal behavior.

1. Introduction

Prior to developing a waste management strategy, policy makers should identify the major forces driving the creation of hazardous and other wastes embodied in the domestic economy. The validity of a waste management strategy cannot be assessed without such a determination.

To develop a plan for reducing the final disposal quantity of waste oil, for example, it is not sufficient to only consider improvements in recycling technology for inter-

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mediate reuse of waste oil. Improvements in recycling technology alone may not result in a reduction in final disposal quantities because of another fundamental problem. The volume of intermediate and final waste generation largely depends on factors that affect final demand, such as the volume and structural pattern of household consumption expenditure, exports, and capital investment.

The present study focuses on the Input-Output Theory established by Nobel laureate Wassily Leontief (1951) and on the System of National Account (Make-Use Theory) established by Nobel laureate Richard Stone (1961). These two theories are interrelated (see, for example, Chapter 5 of Miller & Blair, 1985) and the use of both theories facilitates the resolution of the above-mentioned problem. The Life Cycle Inventory Assessment based on these theories, often called Economic Input-Output Analysis Life-Cycle Assessment (EIO-LCA), has often been performed in environmental engineering to measure the domestic economy's primary and secondary energy requirements, as well as levels of air pollution emissions (see Lave et al., 1995; Hendrickson et al., 1997; Hendrickson & Horvath, 1998; Horvath & Hendrickson, 1998a, 1998b; Rosenblum et al., 2000). Similar research has also been completed using environmental input-output models in the field of environmental sciences.

However, estimated results of waste analyses are sometimes difficult to assess due to practical and theoretical problems with both the input-output theory and the make-use theory. In Japan, physical waste input-output tables cannot be directly obtained from waste survey data, thus the practical problem relates to inaccuracies in the estimation methods. While this problem may be fundamental to all waste input-output analyses, estimates for waste input-output tables can still be made.

Ohira et al. (1998) successfully estimated the physical industrial waste output table for 1993, and estimated direct and indirect final disposal quantities generated by the Japanese economy using a non-competitive imports input-output model. This empirical analysis elucidated the relationship between the waste generation structure and the Japanese economic system.

This paper generalizes the Ohira's analysis. Since multiplication of the industrial waste output matrix showing the output of the industrial waste per unit production for each industry by the Leontief inverse showing the direct and indirect commodity production induced by the final demand of each commodity is not possible precisely, the commodity-by-commodity input-output table was converted into the industry-by-industry input-output table or equivalently the waste-by-industry table was converted into the waste-by-commodity table by following the make-use theory.

The employment of the make-use theory requires either the commodity technology assumption or the industry technology assumption (Kop Jansen & ten Raa, 1990). It should be noted that the former presumes that a commodity has the same input structure regardless of its product-mix structure, while the latter presumes that all commodities produced within an industry utilize the same input structure. However, if the waste-by-commodity table showing physical output data for each industrial waste per unit production of each commodity can be directly obtained using waste survey data, then the above-mentioned assumptions are not required. The waste-by-commodity table cannot be constructed directly because most Japanese waste survey data is based on waste generation data from individual firms, not from production processes.

Consequently, to connect the industrial waste output matrix with the Leontief inverse, the make-use theory must be considered. In the present study, we employed the industry technology assumption to construct the Leontief inverse and measured the industrial wastes embodied in the Japanese economy.

The important features of our study are: (1) the construction of a waste generation matrix and a landfill matrix (57 industrial wastes) for 1995 (using industrial waste data collected by each local government) that shows the generations and landfills of each industrial waste type generated by the production units in each industry; and (2) the application of the 1995 waste generation matrix to the non-competitive imports input-output model, which enabled us to determine the major economic forces driving the embodied waste generation from the viewpoint of the domestic waste balance. Hence, the waste generation model presumes that the waste generation structure of foreign countries is *not* identical to that of Japan where the technology of the domestic commodity under consideration is *not* perfectly competitive with that of the imported commodity.

The present analysis was conducted in the sprit of Ohira et al. (1998) but did not consider the discussion of the waste recycling structure (see for example Duchin, 1990; Nakamura & Kondo, 2002a, 2002b; Kagawa et al., 2002). Professors Nakamura & Kondo demonstrated that the use of the correspondence matrix between industrial wastes and recycling activities could account for the intermediate inputs (energy and/or materials) directly and indirectly required for the recycling activities. Although the waste input-output analysis plays a crucial role in estimating environmental and economic impacts of introduction of the waste recycling technology and its improvement, this is not within the scope of the paper as is mentioned above.

This paper is organized as follows: following the introduction, section 2 briefly formulates the waste generation model, section 3 illustrates the application of basic data, and section 4 shows the empirical results. Finally, section 5 is the summary of the major findings and conclusions.

2. Waste Generation Model

Industrial waste generation can be formulated as

$$Q = Wg \tag{1}$$

where $Q=(Q_i)$ is the waste generation vector showing the physical generation of each industrial waste, i; $W=(W_{ij})$ is the waste output coefficient matrix showing the physical generation of each industrial waste, i, per unit production for each industry, j; and $g=(g_i)$ is the total industrial output vector showing the monetary value of total domestic output for each industry, j. More concretely, the jointly generated industrial wastes can be generally categorized into marketable wastes, with positive values, and non-marketable wastes with negative values. By focusing on the latter wastes, the waste output coefficient matrix can be constructed. When the types of industrial wastes and industries are classified m and n, respectively, equation (1) can be rewritten as

$Q_i = \sum_{j-1}^{n} W_{ij} + g_j \ (i = 1,\cdots\cdots,m)$.

The present paper employed the industry technology assumption in order to construct the technical matrix $A=(a_{ij})$ showing the intermediate input requirement of each commodity, i (including imported commodity i), per unit production of each commodity, j. Following the assumption, the technical matrix can be constructed as $a_{ij} = \sum_{k=1}^{n} b_{ik} d_{kj} \Leftrightarrow A = BD$ where $B=(b_{ik})$ represents the use matrix showing the intermediate input requirement of each commodity, i , per unit production of each industry, k , and $D=(d_{kj})$ describes the market share of industry, k, which produce commodity, j. Hence, it holds that

$$g = Dq \tag{2}$$

if $q=(q_j)$ is the total commodity output vector showing the monetary total domestic output of each commodity, j. Substituting the Leontief material balance (the commodity use balance), $q = Ag+F+E-M$, where F is the domestic final demand vector, which can be decomposed into the nine components: F_{hoe}(consumption expenditure outside households); F_{hie} (consumption expenditure of households); F_{gov} (consumption expenditure of central and local government); F_{pub} (gross domestic fixed capital formation (public)); F_{pri} (gross domestic fixed capital formation (private)); F_{adj} (increase in stocks); F_{exp} (exports); F_{hni} (consumption expenditure of private non-profit institutions); F_{etc} (etc.); E is the exports vector; and, M is the imports vector, into equation (2) yields $g = D\,(I-A)^{-1}(F+E-M)$. This is the straightforward competitive imports input-output model. From the model and equation (1), the industrial waste generation can be finally formulated as

$$Q^c = WD\,(I-A)^{-1}(F+E-M) \tag{3}$$

where the superscript c denotes the competitive imports type.
If the landfill rate showing the quantity of waste reclamation for final disposal, per unit of the total emission of industrial waste, i , generated by each industry, j, can be defined as $G=(G_{ij})$, the quantities of the landfill of industrial wastes directly and indirectly induced by the final demand can be formulated as

$$Y^c = G \circ WD\,(I-A)^{-1}(F+E-M) \tag{4}$$

where denotes the Hadamar product showing element-by-element multiplication.
Similarly, the industrial waste generations and landfills could be formulated as

$$Q^{nc} = WD\,(I-A^d)^{-1}(F^d+E) \tag{5}$$

and

$$Y^{nc} = G \circ WD\,(I - A^d)^{-1}(F^d + E) \tag{6}$$

where $A^d=(a_{ij}^d)$ represents the intermediate input requirement of each domestic commodity, i (excluding imported commodity, i) per unit production of each commodity, j, F^d is the domestic final demand vector of domestic commodities, and the superscript nc denotes the non-competitive imports type.[1] As is mentioned above, the domestic final demand of the domestic commodities can be further decomposed into the nine components.[2] In this case, we can not say that A^d states the commodity production technologies, because engineers do not care whether the material used is a domestic commodity or not. Equations (5) and (6) simply describe the waste generations and final waste disposals directly and indirectly induced by the intermediate input structure related to the domestic commodities. Hence, equations (5) and (6) do not consider the waste generation and landfills internationally induced by the production of imported commodities.

3. Basic Data

For the empirical analysis, we constructed the 1995 waste generation matrix focused on the 69 industrial wastes corresponding to the matrix W and the 1995 landfill ratios corresponding to the matrix G from the waste survey data.[3] The terminology, industrial waste, is used in our study to indicate the wastes that were generated in commodity production. Hence, we did not consider the wastes that were generated by households and government consumption. This definition indicates that the wastes related to household durable goods, for example, waste automobiles and waste computers, and those related to household non-durable goods, for example, kitchen garbage and waste paper, were not evaluated (the gray-shaded portion of Figure 1 defines the scope of our study).

In addition, the estimated matrices have two limitations. First, agriculture-oriented wastes were not considered due to a reliability of basic data; therefore, the waste generation matrix was underestimated. More concretely, the industrial wastes related to agriculture, livestock-raising & sericulture, agricultural services, and forestry, for example, the dung and urine of animals and animal corpses, were completely omitted. Secondly, the present analysis does not include the marketable industrial wastes that have positive market prices. We have to say that there is no special reason for it and simply the marketable waste was out of scope in this paper.

Under these preconditions, 66 industrial wastes were categorized. Appendix A shows the 57 industrial wastes and the 9 hazardous wastes.

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[1] If $A^m = (a_{ij}^m)$ represents the intermediate input requirement of each imported commodity, i, per unit production of each commodity, j, and F^m is the domestic final demand vector of the imported commodities, it holds that $A = A^d + A^m$ and $F = F^d + F^m$ (see Miller & Blair, 1985).

[2] It holds that $F^d = F^d_{hoe} + F^d_{hie} + F^d_{gov} + F^d_{pub} + F^d_{pri} + F^d_{adj} + F^d_{exp} + F^d_{kni} + F^d_{exp}$..

[3] The waste data will be available to the general public in the near future.

Figure 1: Scope of our study

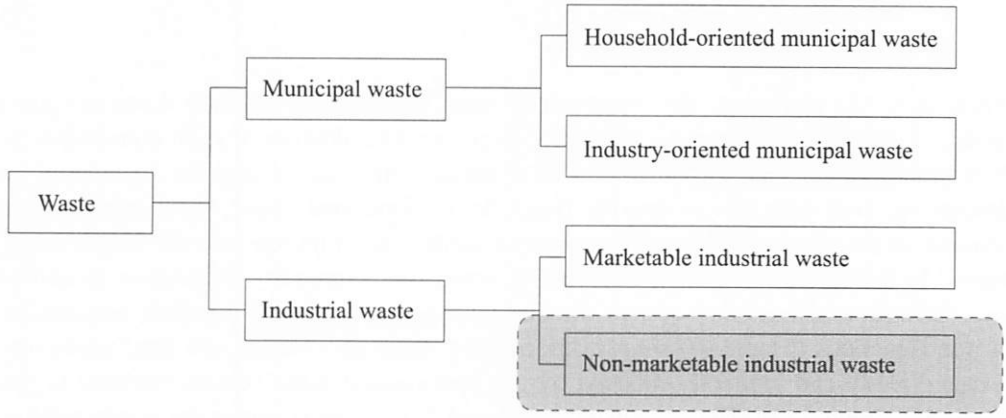

Table 1: Comparison with official values

Industrial wastes	Former ministry of health and welfare		The present study (non-marketable wastes)	
	Emissions (thousand tons)	Ratio (%)	Emissions (thousand tons)	Ratio (%)
1. Incineration ash	3,258	0.8	2,194	0.7
2. Sludge	185,508	47.1	216,293	67.0
3. Waste oil	3,173	0.8	2,832	0.9
4. Acid waste fluid	4,441	1.1	3,433	1.1
5. Alkaline waste fluid	2,020	0.5	1,292	0.4
6. Waste plastics	6,253	1.6	6,401	2.0
7. Waste papers	1,897	0.5	1,784	0.6
8. Wood chips	7,161	1.8	6,112	1.9
9. Waste fiber	84	0.0	132	0.0
10. Waste residuals of animals and plants	3,961	1.0	1,880	0.6
11. Waste rubber	87	0.0	81	0.0
12. Waste metal	6,482	1.6	4,503	1.4
13. Waste glass and ceramics	6,067	1.5	5.380	1.7
14. Slag	24,242	6.2	14,007	4.3
15. Construction wastes	58,460	14.8	48,687	15.1
16. Dung and urine of animals	72,996	18.5	—	—
17. Animal corpse	145	0.0	—	—
18General waste particles	7,578	1.9	7,976	2.5
Total	393,812	100.0	322,989	100.0

To estimate the 1995 waste generation matrix, we tried to isolate the industrial wastes to prevent the problem of double counting the industrial waste types. For example, the sludge generated by several industries is generally dehydrated and then called dehydrated sludge. Combining the volume of sludge with dehydrated sludge would account for certain sludge types twice, presuming that the sludge types are homogeneous waste. If they can be regarded as heterogeneous wastes, the double counting problem is not significant. The waste generation matrix and the landfill matrix were constructed by considering the potential for the double counting problem.[4]

Table 1 shows the comparison between official values and our estimations. The considerable differences that exist between the official value and our estimations are explained below. First, our estimations treat only non-marketable wastes, while official emission reports include both the marketable and non-marketable wastes. Although both values potentially include errors, the official values are actually larger than our estimations except for sludge, waste plastics, and waste fiber (see totals in Table 1). Secondly, there are differences in sample size, and because the accuracy of the official sample size is not known, the difference cannot be refined.

The input coefficient matrices of the competitive and noncompetitive imports types, A and A^d, were expressed in 1995 price indices and aggregated to 92 sectors. We also treated the domestic market share matrix, D, in the same way. Appendix B shows the sector classifications.

4. Empirical Results

4.1. Embodied industrial waste intensities

Figure 2 shows the top ten sectors of the waste generation intensities (kg) embodied in the unit final demand (one million yen) of each commodity.[5] Figure 3 shows the top ten sectors of the landfill intensities (kg) embodied in the unit final demand (one million yen) of each commodity under the same condition.[6]

The comparison between the waste generation intensities of the top ten sectors and the sectoral average 1,274 (kg/million yen) definitely indicates that there are significant differences in sectoral waste generation intensities. The waste generation intensities of non-ferrous metal ores (No.13) and water supply & sewage (No.64), were especially large, approximately 16–17 times larger than the sectoral average (see Figure 2). The two commodities greatly contributed to the direct generations of other inorganic sludge and sewerage sludge, respectively. Pulp & paper (No.27) also contributed to the direct and indirect generation of other organic sludge, mainly paper sludge.

Naturally, commodities such as miscellaneous ceramic, stone & clay products (No.42) and cement & cement products (No.40) which need a large quantity of non-ferrous metal ores as raw materials, indirectly bring about the generation of the other inorganic sludge and thus show high indirect effects (28% for miscellaneous ceramic, stone & clay products; and, 65% for cement & cement products). In addition, the percentage of indirect effects from processed paper products (No.28) was extremely high (83%) because the processed paper products sector intermediately inputs pulp & paper products and indirectly generates a large quantity of paper sludge.

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[4]. Knowledge of the separated water generation volumes is crucial for the performance of the material flow analysis. Please contact with us for detailed contents of the data.

[5] The direct and indirect effects of the waste generations were formulated as

$$Q^{nc}_{direct} = Wd\ (F^d + E) \text{ and } Q^{nc}_{indirect} = WD\ (A^d + (A^d)^2 + \cdots)(F^d + E),$$

respectively.

[6] Similarly, the direct and indirect effects of the landfills can be formulated as

$$Y^{nc}_{direct} = G \circ WD\ (F^d + E) \text{ and } Y^{nc}_{indirect} = G \circ WD\ (A^d + (A^d)^2 + \cdots)(F^d + E),$$

respectively.

A comparison of Figures 2 and 3 demonstrates the sectoral differences in intermediate waste disposal and landfill. The intensities of non-ferrous metal ores (No.13), miscellaneous ceramic, stone & clay products (No.42) and non-ferrous metals (No.46) were extremely high mainly due to direct generation of other inorganic sludge with a sectoral average of landfill intensities at 239 kg/million yen. In addition, the percentage of indirect effects of cement & cement products (No.40) was about 57% of the direct and indirect effects and relatively high.

These results for the cement & cement products industry indicate that even if a concerned industry reduced its direct landfill intensity (its landfill quantity per unit production), the direct reduction effect may be less than half of the direct and indirect intensity. In fact, from the bar graph of cement & cement products in Figure 3, it can be seen that even if cement & cement products industries reduce the direct intensity by 10% (44.2 kg/million yen), for example, the reduction effect is only 4.3% of the direct and indirect intensity. This indicates that the material composition effect is more important than the technique effect. In order to evaluate both effects, the total direct landfill intensity per unit of the total direct generation intensity, the direct landfill ratio (DLR), should be distinguished from the total indirect landfill intensity per unit of the

Figure 2: Top ten sectors of the embodied waste generation intensities (kg per one million yen)

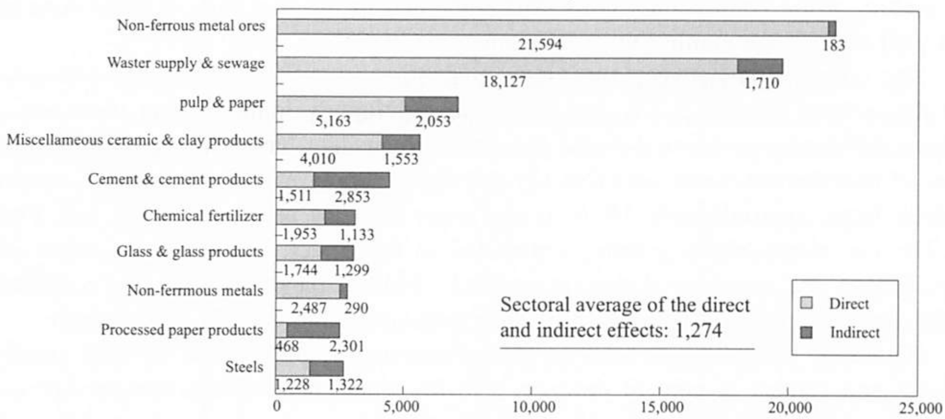


Figure 3: Top ten sectors of the embodied landfill intensities (kg per one million yen)

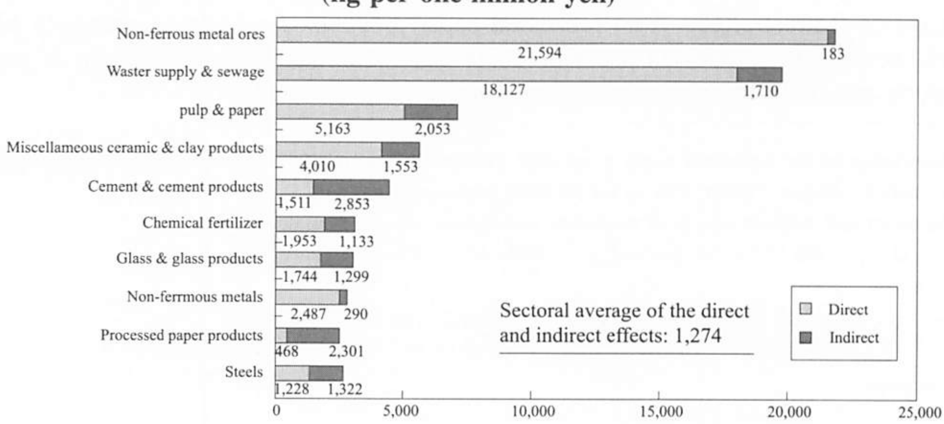


Table 2: DLR and ILR of the top ten sectors of the landfill intensities

Sectors (No.)	DLR (%)	ILR (%)
1. Non-ferrous metal ores	19	17
2. Miscellaneous ceramic, stone & clay products	53	24
3. Non-ferrous metals	89	44
4. Cement & cement products	29	21
5. Water supply	3	7
6. Industrial inorganic chemicals	24	27
7. Steels	18	26
8. Pulp & paper	7	9
9. Pig iron & crude steel	30	28
10. Steel products	59	23
*** Non-ferrous metal products	24	65

Note: Non-ferrous metal products show the highest value of IFDR.

total indirect generation intensity, the indirect landfill ratio (ILR). The former stands for self-contribution to landfill through the joint-production technology, while the latter describes other industries' contributions through the material composition (indirect material use).

Table 2 shows the DLR and the ILR of the top ten sectors of the landfill intensities. Of the top ten sectors, water supply & sewage (No.64) and pulp & paper (No.27) show very low DLR and ILR in comparison with other sectors. This implies that, in 1995, the two sectors were minor sectors when considering landfill volumes embodied by unit production. In addition, while the non-ferrous metal products sector (No.47) was below the top ten sectors in rank for direct and indirect landfill intensities, its ILR was the highest among all the sectors. The main reason for this is that the non-ferrous metal products sector indirectly contributed to the landfill quantities largely through economic transaction with non-ferrous metals (No.46) and wholesale trade & retail trade (No.66). Thus, in those sectors showing a high value of ILR, other related industry contributions to the landfill quantity are more significant.

4.2. Embodied industrial waste generation

4.2.1. Sectoral contributions

Readers may also be interested in the industrial waste generations embodied by (directly and indirectly induced by) the actual final demand. In this section, the industrial waste quantities directly and indirectly induced by each final demand category are discussed.

Figure 4 shows the top ten sectors of embodied waste generation (million tons) for each commodity. Figure 5 shows the top ten sectors of the embodied landfill quantities (million tons) of each commodity under the same condition.

The figures show that, in the 1995 Japanese economy, the construction sector (No.63) greatly contributed to both industrial waste generation and the landfill quantities not only through direct production to satisfy its own final demand but also through the indirect production of the non-ferrous metal ores (No.13), cement & cement products (No.40), and miscellaneous ceramic, stone & clay products (No.42) required for construction activities.

An especially large quantity of other inorganic sludge was indirectly created by the other production activities and the total indirect effect of the construction sector was about 65%, which corresponds to 38.7 million tons. Due to the high values of the DLR and ILR for non-ferrous metal ores, cement & cement products, and miscellaneous ceramic, stone & clay products from Table 2, there is physical limit to the reduction in the direct and indirect landfill quantities that could be achieved through the technological improvement of construction sector alone. Comprehensive programs focusing on the above-mentioned major technology chains related to the construction sector are needed to realize a reduction in the final disposal quantity.

Although certain sectors do not directly generate the industrial wastes, they may indirectly contribute to the waste generations and landfills on a large scale. A sector representative of this circumstance is house rent (No.69). While this sector did not generate much industrial waste directly, its contribution to landfill volume was relatively high in comparison with other sectors (see Figure 5). This contribution depended completely on the waste generation structure of the construction sector.

Figure 4: Top ten sectors of the embodied waste generation (million tons)

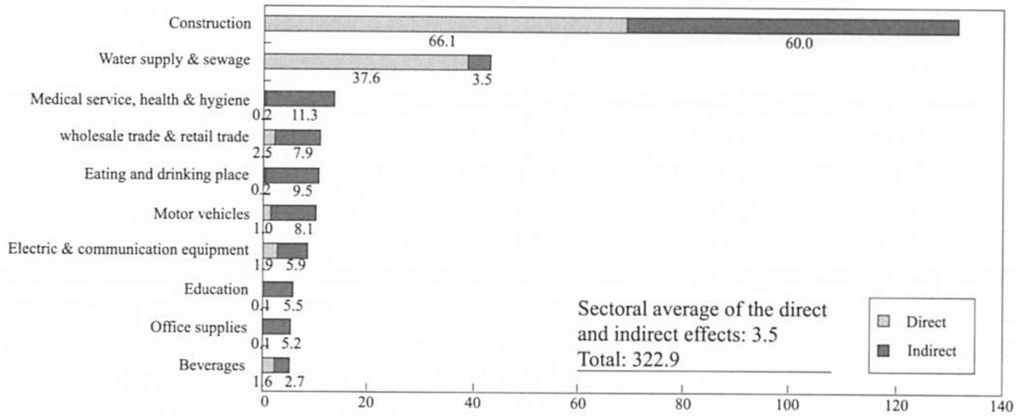
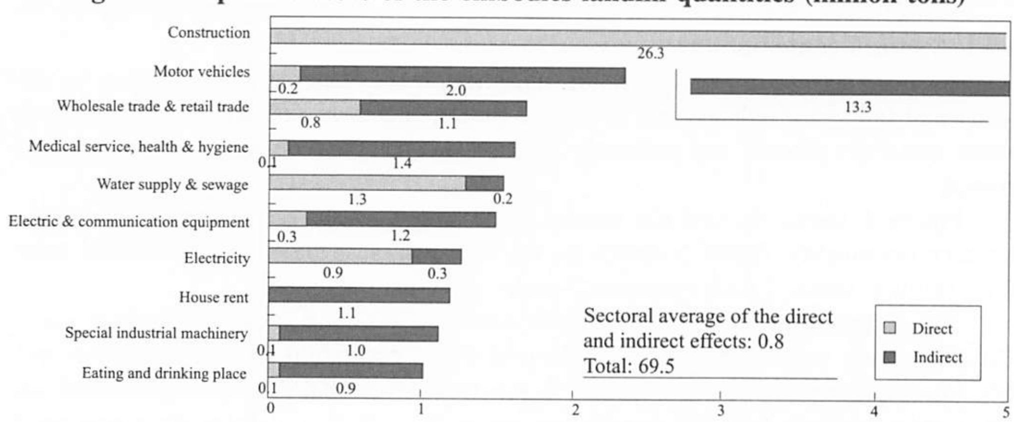


Figure 5: Top ten sectors of the embodies landfill quantities (million tons)



Special industrial machinery (No.51) and eating and drinking place (No.88) operate under circumstances similar to the house rent category. The former indirectly contributed to the landfill quantities of other inorganic sludge, unclassified slag, and general waste particles through the production activities of pig iron & crude steel (No.43) and steels (No.44), while the latter not only contributed to the landfill quantities of other inorganic sludge through the production activities of non-ferrous metal ores (No.13) and glass & glass products (No.39), but also contributed to the landfill quantities of inorganic acid waste fluids through the production activities of sugar & other foods (No.19) and beverages (No.20). These indirect effects were remarkable in the 1995 Japanese economy (see Appendix C and D for more detailed sectoral contributions). In contrast, water supply & sewage (No.64) also shows a large volume of industrial waste generation, mainly sewage sludge and waterworks sludge, but this sector only marginally contributes to the landfill quantity, as seen in the very low value of the DLR and ILR.

4.2.2. Contributions of final demands

Table 3 and Table 4 show the contributions of the final demands to the embodied waste generation volume and the embodied landfill quantities, respectively. Figure 6 and Figure 7 show the contributions to the final demands by each industrial sector.

From Figure 6 and 7, we can understand the major economic driving forces of embodied waste generation volume (322,894 thousand ton) and the embodied landfill quantity (69,454 thousand ton) in the 1995 Japanese economy. For the volume of generated embodied waste generated the consumption expenditure of households shows the highest percentage 32.0% (about 100,000 thousand ton) and was the major driving force. This result also reveals that household consumption behavior leads to about three times the amount of the household-oriented municipal wastes (about 35,000 thousand ton) generated by direct household disposal behavior which was published in the report on the 1995 Japanese waste treatment (the former Ministry of Health and Welfare).[7] For the landfill, the gross domestic fixed capital formation (private) shows the highest percentage 38.8%. The findings are similar with Ohira's results (see Table 3 and Table 6 of Ohira et al. (1998)).

Subsequently, by computing the total contribution of each sector's final demand to the landfill quantities per unit of the total contribution of each sector's final demand to waste generation from Table 3 and Table 4, we can determine which final demand structure was most sensitive to the landfill activity. For example, computing the value of the consumption expenditure outside households yields 0.12 (=929/7,741). The computations reveal that the public gross domestic fixed capital formation and the private gross domestic fixed capital formation show relatively high values, 0.31 and 0.30, respectively, and were very sensitive to the landfill quantities, while the consumption expenditure of households was not as sensitive, when compared with the above-mentioned final demand structures.

The induced effect of the public gross domestic fixed capital formation and the private

[7] The breakdown of the firm- and household-oriented municipal wastes is given as mixed refuse, 7,570 thousand ton; combustible refuse, 28,670 thousand ton; incombustible refuse, 4,540 thousand ton; recycling refuse, 1,740 thousand ton; bulky waste etc., 1,580 thousand ton. Using this statistics and other statistics, we estimated 35,000 thousand ton of "the household-oriented municipal wastes".

Figure 6: Contributions of the final demands to the embodied waste generarion

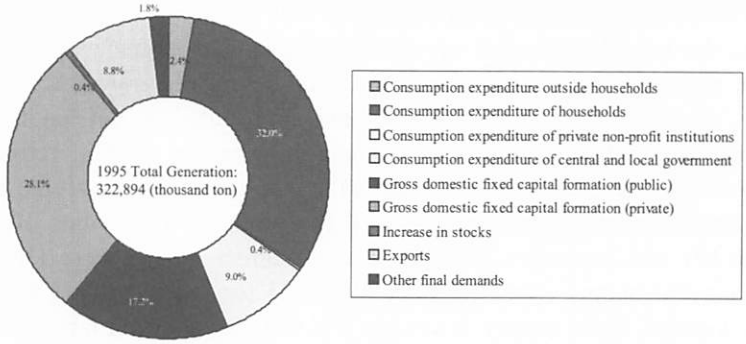
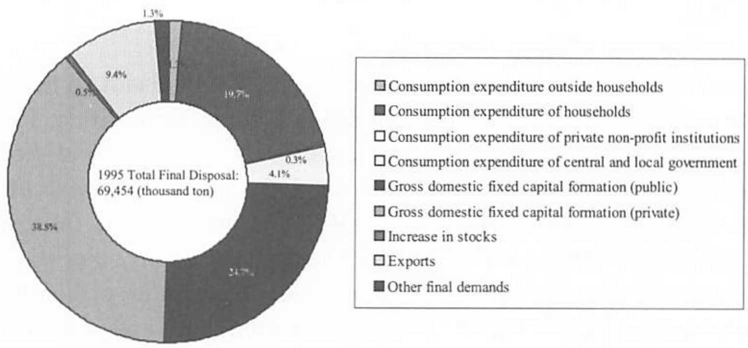


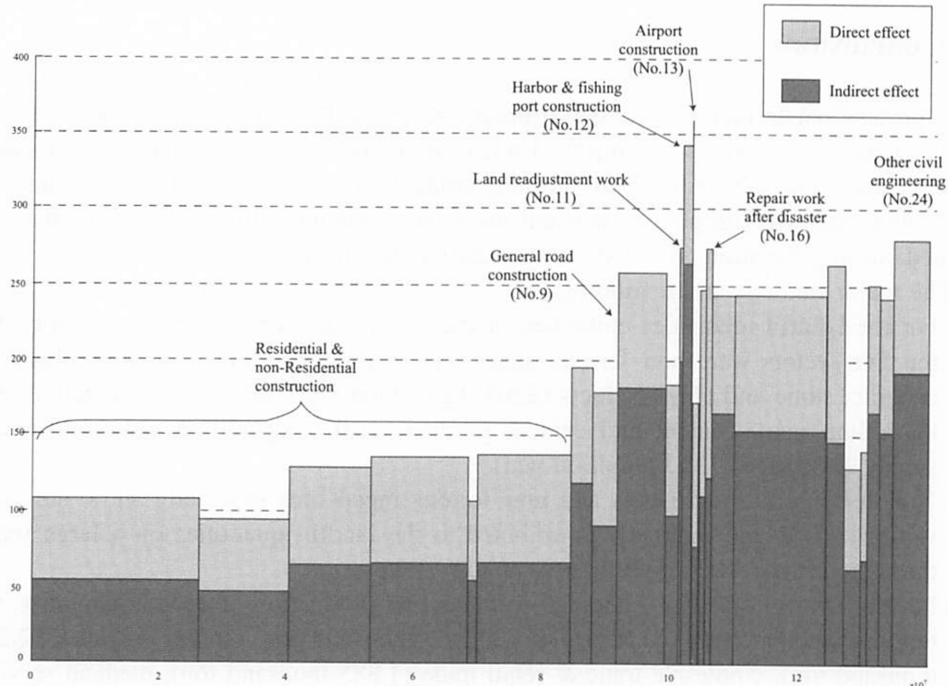
Figure 7: Contribution of final demands to the embodied landfill quantities



gross domestic fixed capital formation largely depends on the production technology of the construction sector. In fact, Table 4 shows that the landfill quantities of construction sludge, waste concrete, and other construction wastes were large in 1995.

Figure 8 shows a bird's-eye view of the landfill quantity induced by the domestic public and private fixed capital formation. The horizontal axis describes gross domestic fixed capital formation by each construction category (see Appendix E), while the vertical axis describes the landfill intensity embodied in each unit construction activity (one million.yen). Accordingly, each area obtained by multiplying the horizontal length for each construction work with its vertical length, represents the landfill quantity for each construction work. Comparison between Residential & Non-residential construction activity and Civil engineering shows that the landfill quantity by the former was driven mainly by the volume of investment demand rather than by the intensity which definitely indicates embodied waste emission structure for the unit investment demand, while the latter generally shows the opposite phenomenon. We find that although Airport construction (No.13), Harbor & fishing port construction (No.12), Land readjustment work (No.11), Repair work after disaster (No.16), Other civil engineering (No.24) and General road construction (No.9) were remarkable for the intensity, the landfill quantities induced by these construction activities were relatively low because of the very low investment demands (see section 4.2.1 for the average emission intensity (quantity) of the construction sector). We believe that these results and findings would be useful for discussing compatibleness with future public and private investment planning and landfill planning.

Figure 8: Bird's-eye view of landfill waste quantity induced by domestic public and private capital formation



4.3. Short discussion

Through empirical investigations, the relevance of focusing on the construction sector can be seen, as construction contributes to domestic fixed social capital formation, and adds to the landfill capacity problem of Japan. The landfill capacity problem necessitates careful observations of the relationship between the direct and indirect landfill quantities and enables us to demonstrate the empirical validity of the zero–emission movements which fundamentally aim not to emit wastes in every sense. This may implicitly support the importance of the zero–emission movement of the construction sector. Policy–makers supporting the zero–emission movement need to distinguish between the direct generation of the landfill quantities and the indirect generations. The distinction would consequently provide us the answer to the question of whether or not zero–emission movements of construction sector truly led to saving energy, raw materials and services and to reducing final waste disposal quantity.

For the construction sector, especially, it is crucial to include the direct emissions from construction sludge, waste concrete, and other construction wastes as well as to consider the indirect emissions from the production processes of miscellaneous ceramic, stone & clay products, non–ferrous metals, steel products, and plastic products which show very high values of DLR and ILR. In fact, the indirect effects of the landfill quantities were at approximately 34% and thus very high.

5. Conclusions

The present paper investigated the structure of the industrial waste embodied in the 1995 Japanese economy. The empirical results demonstrate which industrial waste were directly and indirectly induced by the unit production of each commodity and then finally disposed. We can also understand the major economic driving forces of the embodied waste generation and of the embodied landfill quantities.

The major findings are as follows:

(1) For the landfill intensities embodied in the unit production of each commodity, the top five sectors were non-ferrous metal ores (4,132 kg/million yen), miscellaneous ceramic, stone and clay products (2,510 kg/million yen), non-ferrous metals (2,334 kg/million yen), cement and cement products (1,030 kg/million yen), and Water supply & sewage (722 kg/million yen).

(2) Non-ferrous metal products and non-ferrous metal ores especially show the large values of ILR and indirectly contributed to the landfill quantities on a large scale, throughout the entire domestic economic system.

(3) For the landfill quantity embodied in the actual production of each commodity, the top five sectors were construction (39,592 thousand ton), motor vehicles (2,250 thousand ton), wholesale trade & retail trade (1,885 thousand ton), medical service, health & hygiene (1,558 thousand ton) and Water supply & sewage (1,499 thousand ton). At least these five sectors were responsible for the landfill capacity problem in the 1995 Japanese economy.

(4) The major economic driving forces of the embodied landfill quantities were gross domestic private capital formation (38.8% of total final disposal quantity 69,454 thousand ton) and gross domestic public capital formation (24.7%). These results indicate that the contribution of the final demand structures to the reduction in the landfill quantity was significant.

(5) The result also reveals that household consumption behavior leads to about three times the amount of the household-oriented municipal wastes (about 44,100 thousand ton) generated by direct household disposal behavior which was published in the report on the 1995 Japanese waste treatment (the former Ministry of Health and Welfare).

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Appendix A: Industrial waste classifications (66 sectors)

20 industrial wastes	57 industrial wastes
1. Incineration ash	1. Waste active carbon · waste carbon 2. Unclassified incineration ash
2. Sludge	3. Sewerage sludge 4. Other organic sludge 5. Construction sludge 6. Waterworks sludge 7. Other inorganic sludge
3. Waste oil	8. Mineral oil 9. Oils and fats of animals and plants 10. Benzine 11. Unclassified general waste fluid 12. Waste solvents 13. Solid oil 14. Oil mud 15. Clothes including oil
4. Acid waste fluid	16. Inorganic acid waste fluid 17. Waste fluid from photographic fixing 18. Corrosive waste fluid 19. Strong acid waste fluid
5. Alkaline waste fluid	20. Alkaline waste fluid 21. Developing solution of photograph 22. Strong alkaline waste fluid
6. Waste plastics	23. Synthetic fiber 24. Fiber reinforced plastic 25. Plastics plasticized by high heat 26. Resins reinforced high heat 27. General scrap plastics 28. Synthetic rubber 29. Agricultural plastic wastes 30. Waste tires
7. Waste papers	31. Waste papers
8. Wood chips	32. Wood chips
9. Waste fiber	33. Waste fiber

20industrial wastes	57 industrial wastes
10. Waste residuals of animals and plants	34. Waste residuals of animals 35. Waste residuals of plants 36. Unclassified waste residuals of animals and plants
11. Waste rubber	37. Waste rubber
12. Waste metal	38. Waste metal
13. Waste glass and ceramics	39. Waste glasses 40. Waste ceramics 41. Plaster board 42. Asbestos etc. 43. Unclassified waste glass and ceramics
14. Slag	44. Waste sand 45. Blast furnace slag 46. Slag 47. Unclassified slag
15. Construction wastes	48. Waste concrete 49. Waste asphalt 50. Other construction wastes
16. General waste particles	51. General waste particles
17. Dung and urine of animals	52. Dung and urine of animals
18. Animal corpse	53. Animal corpse
19. Others	54. Solid concrete wastes
	55. Shredder dust
	56. Unclassified wastes
	57. Melting wastes
20. Hazardous wastes	Incineration ash including toxic substance Organic sludge including toxic substance Inorganic sludge including toxic substance Waste oil including toxic substance Acid waste fluid including toxic substance Alkaline waste fluid toxic substance Slag including toxic substance Waste particles including toxic substance Infectious medical wastes

Appendix B: Industry (Commodity) classfications (92 sectors)

No. Industry (commodity) sectors (1–46)	No. Industry (commodity) sectors (47–92)
1. Coal mining & lignite	47. Non-ferrous metal products
2. Crude petroleum & natural gas	48. Metal products for construction and architecture
3. Petroleum refinery products	49. Other metal products
4. Coal products	50. General industrial machinery
5. Electricity	51. Special industrial machinery
6. Gas supply, steam & hot water supply	52. Other general machines
7. Agriculture	53. Office machines & machinery for service industries
8. Livestock-raising & sericulture	54. Household electric appliances
9. Agricultural services	55. Electric & communication equipment
10. Forestry	56. Heavy electrical equipment
11. Fisheries & culture	57. Other electrical equipment
12. Metal ores	58. Motor vehicles
13. Non-ferrous metal ores	59. Ships & their repair
14. Slaughtering & meat processing	60. Other transport equipment & its repair
15. Livestock-raising foods	61. Scientific instruments
16. Seafood	62. Miscellaneous manufacturing products
17. Grain milling & flour	63. Construction
18. Preserved agricultural foodstuffs	64. Water supply & sewage
19. Sugar etc & other foods	65. Waste disposal services
20. Beverages	66. Wholesale trade & retail trade
21. Feeds & organic fertilizers	67. Financial service & insurance
22. Tobacco	68. Real estate rental service
23. Fabricated textile products	69. House rent
24. Apparel & other textile products	70. Railway transport
25. Timber & wooden products	71. Road transport
26. Furniture & fixtures	72. Ocean transport & coastal transport
27. Pulp & paper	73. Air transport
28. Processed paper products	74. Storage facility service
29. Printing & publishing	75. Services relating to transport
30. Chemical fertilizer	76. Telecommunication
31. Industrial inorganic chemicals	77. Broadcasting
32. Industrial organic chemicals	78. Education
33. Resins	79. Research
34. Chemical fibers	80. Medical service, health & hygiene
35. Final chemical products	81. Other public services
36. Plastic products	82. Advertising services
37. Rubber products	83. Information services
38. Leather, leather products & fur skins	84. Goods rental & leasing
39. Glass & glass products	85. Repair of motor vehicles and machine
40. Cement & cement products	86. Other business services
41. Pottery, china & earthenware	87. Amusement and recreation services
42. Miscellaneous ceramic, stone & clay products	88. Eating and drinking place
43. Pig iron & crude steel	89. Hotel and other lodging places
44. Steel	90. Other personal services
45. Steel products	91. Activities not elsewhere classified
46. Non-ferrous metals	92. Office supplies

Appendix C: Embodied waste intensities (generation)

No.	Industry (Commodity) sectors (1-46)	Embodied waste intensities (kg per one million yen)			Embodied waste generations (Thousand tons)		
		Direct	Indirect	Total	Direct	Indirect	Total
1.	Coal mining & lignite	0	225	225	0	0	0
2.	Crude petroleum & natural gas	0	176	176	0	0	0
3.	Petroleum refinery products	35	50	85	182	262	444
4.	Coal products	310	601	911	8	15	22
5.	Electricity	431	198	630	2,004	922	2,927
6.	Gas supply, steam & hot water supply	33	272	306	35	287	322
7.	Agriculture	0	243	243	0	697	697
8.	Livestock-raising & sericulture	0	277	277	0	99	99
9.	Agricultural services	0	307	307	0	35	35
10.	Forestry	57	123	180	31	67	98
11.	Fisheries & culture	1	119	121	1	71	72
12.	Metal ores	552	243	794	1	0	1
13.	Non-ferrous metal ores	21,594	182	21,776	−295	−2	−297
14.	Slaughtering & meat processing	15	268	283	13	225	238
15.	Livestock-raising foods	476	431	908	1,096	993	2,088
16.	Seafood	154	263	417	608	1,043	1,651
17.	Grain milling & flour	30	236	266	80	636	716
18.	Preserved agricultural foodstuffs	312	388	700	1,558	1,933	3,491
19.	Sugar etc & other foods	531	374	904	2,445	1,723	4,168
20.	Beverages	260	433	693	1,618	2,688	4,306
21.	Feeds & organic fertilizers	94	305	399	9	28	37
22.	Tobacco	21	92	113	59	256	315
23.	Fabricated textile products	336	508	844	283	428	711
24.	Wearing apparel & other textile products	60	371	430	314	1,946	2,260
25.	Timber & wooden products	652	310	962	40	19	58
26.	Furniture & fixtures	130	588	717	190	862	1,052
27.	Pulp & paper	5,163	2,053	7,216	2,754	1,095	3,849
28.	Processed paper products	468	2,301	2,769	502	2,467	2,969
29.	Printing & publishing	97	1,033	1,130	159	1,685	1,844
30.	Chemical fertilizer	1,933	1,132	3,065	−65	−38	−104
31.	Industrial inorganic chemicals	1,684	824	2,508	293	143	436
32.	Industrial organic chemicals	1,053	868	1,921	1,227	1,011	2,238
33.	Resins	232	1,094	1,326	129	608	737
34.	Chemical fibers	306	810	1,116	57	151	208
35.	Final chemical products	229	565	794	874	2,152	3,026
36.	Plastic products	116	567	683	114	557	671
37.	Rubber products	83	569	651	67	461	528
38.	Leather, leather products & fur skins	510	311	821	357	218	575
39.	Glass & glass products	1,744	1,299	3,043	402	299	701
40.	Cement & cement products	1,511	2,853	4,364	90	171	261
41.	Pottery, china & earthenware	553	692	1,245	140	175	314
42.	Miscellaneous ceramic, stone & clay products	4,010	1,553	5,563	1,517	587	2,104
43.	Pig iron & crude steel	836	925	1,761	49	54	104
44.	Steels	1,225	1,320	2,545	1,838	1,981	3,819
45.	Steel products	455	1,000	1,455	13	29	42
46.	Non-ferrous metals	2,487	290	2,776	572	67	639

Appendix C: Embodied waste intensities (generation)

No. Industry (Commodity) sectors (47-92)	Embodied waste intensities (kg per one million yen)			Embodied waste generations (Thousand tons)		
	Direct	Indirect	Total	Direct	Indirect	Total
47. Non-ferrous metal products	243	583	826	187	448	635
48. Metal products for construction, architecture	198	649	847	23	76	100
49. Other metal products	218	625	842	299	857	1,155
50. General industrial machinery	39	478	518	222	2,704	2,926
51. Special industrial machinery	36	409	445	336	3,849	4,185
52. Other general machines	103	505	609	234	1,145	1,378
53. Office machines & machinery for service industry	67	336	403	194	971	1,165
54. Household electric appliance	19	375	393	138	2,750	2,888
55. Electric & communication equipment	102	317	419	1,902	5,929	7,831
56. Heavy electrical equipment	36	408	444	148	1,688	1,836
57. Other electrical equipment	98	417	515	200	849	1,049
58. Motor vehicles	55	446	501	998	8,140	9,138
59. Ships & its repair	66	551	617	100	833	933
60. Other transport equipment & its repair	58	355	413	69	427	496
61. Scientific instruments	48	343	392	144	1,017	1,161
62. Miscellaneous manufacturing products	53	424	477	163	1,319	1,482
63. Construction	826	750	1,575	66,084	60,000	126,083
64. Water supply & sewage	18,127	1,710	19,837	37,609	3,548	41,157
65. Waste disposal services	0	281	281	0	381	382
66. Wholesale trade & retail trade	37	116	153	2,492	7,889	10,381
67. Financial service & insurance	0	100	100	1	895	896
68. Real estate rental service	13	115	128	9	75	84
69. House rent	0	76	76	0	4,022	4,022
70. Railway transport	114	260	374	399	915	1,314
71. Road transport	11	108	119	96	962	1,058
72. Ocean transport & coastal transport	3	94	97	7	225	232
73. Air transport	1	163	164	2	260	263
74. Storage facility service	27	190	217	13	89	102
75. Services relating to transport	10	365	375	31	1,199	1,230
76. Telecommunication	7	101	108	33	464	497
77. Broadcasting	12	179	191	9	134	143
78. Education	4	252	256	79	5,520	5,599
79. Research	12	269	281	10	227	237
80. Medical service, health & hygiene	6	321	327	225	11,309	11,534
81. Other public services	5	207	212	16	742	758
82. Advertising services	1	411	413	0	44	44
83. Information services	0	118	119	2	441	442
84. Goods rental & leasing	5	74	79	9	118	127
85. Repair of motor vehicles and machine	41	284	325	241	1,653	1,894
86. Other business services	27	106	133	173	689	863
87. Amusement and recreation services	5	221	227	65	2,681	2,746
88. Eating and drinking place	9	415	424	217	9,492	9,709
89. Hotel and other lodging places	10	402	412	73	2,814	2,887
90. Other personal services	142	296	438	1,330	2,776	4,105
91. Activities not elsewhere classified	62	343	406	3	16	19
92. Office supplies	3	201	204	77	5,176	5,254

Appendix D: Embodied lanfill intensities (Quantities)

No. Industry (Commodity) sector (1-46)	Embodied waste landfill intensities (kg one million yen)			Embodied waste landfill quantities (thousand tons)		
	Direct	Indirect	Total	Direct	Indirect	Total
1. Coal mining & lignite	0	54	54	0	0	0
2. Crude petroleum & natural gas	0	30	30	0	0	0
3. Petroleum refinery products	10	8	18	51	42	92
4. Coal products	81	123	204	2	3	5
5. Electricity	197	57	254	917	266	1,183
6. Gas supply, steam & hot water supply	4	59	63	4	62	66
7. Agriculture	0	32	32	0	92	92
8. Livestock-raising & sericulture	0	38	38	0	14	14
9. Agricultural services	0	47	47	0	5	5
10. Forestry	7	20	26	4	11	14
11. Fisheries & culture	0	23	24	0	14	14
12. Metal ores	104	45	149	0	0	0
13. Non-ferrous metal ores	4,100	32	4,132	-56	0	-56
14. Slaughtering & meat processing	2	37	39	2	31	33
15. Livestock-raising foods	38	51	90	88	118	206
16. Seafood	28	35	64	112	139	252
17. Grain milling & flour	10	33	42	26	88	114
18. Preserved agricultural foodstuffs	38	52	90	187	260	447
19. Sugar etc & other foods	86	49	135	397	228	624
20. Beverages	43	56	99	264	348	612
21. Feeds & organic fertilizers	7	53	60	1	5	6
22. Tobacco	2	11	13	4	32	36
23. Fabricated textile products	54	84	138	45	71	116
24. Wearing apparel & other textile products	15	60	75	81	313	394
25. Timber & wooden products	40	36	77	2	2	5
26. Furniture & fixtures	22	90	112	32	132	164
27. Pulp & paper	345	180	525	184	96	280
28. Processed paper products	39	182	221	42	195	237
29. Printing & publishing	15	87	103	25	143	168
30. Chemical fertilizer	111	152	263	-4	-5	-9
31. Industrial inorganic chemicals	401	226	626	70	39	109
32. Industrial organic chemicals	243	173	415	283	201	484
33. Resins	52	214	265	29	119	147
34. Chemical fibers	75	141	216	14	26	40
35. Final chemical products	36	96	131	136	364	500
36. Plastic products	41	114	155	40	112	152
37. Rubber products	45	118	163	36	96	132
38. Leather, leather products & fur skins	47	46	93	33	32	65
39. Glass & glass products	114	250	364	26	58	84
40. Cement & cement products	442	588	1,030	26	35	62
41. Pottery, china & earthenware	184	150	334	46	38	84
42. Miscellaneous ceramic, stone & clay products	2,135	375	2,510	808	142	949
43. Pig iron & crude steel	249	259	508	15	15	30
44. Steels	221	339	560	331	509	840
45. Steel products	270	235	496	7	7	14
46. Non-ferrous metals	2,208	126	2,334	508	29	537

Appendix D: Embodied lanfill intensities (Quantities)

No. Industry (Commodity) sector (47-92)	Embodied waste landfill intensities (kg one million yen)			Embodied waste landfill quantities (thousand tons)		
	Direct	Indirect	Total	Direct	Indirect	Total
47. Non-ferrous metal products	58	380	438	45	292	337
48. Metal products for construction, architecture	29	181	210	3	21	25
49. Other metal products	37	159	196	51	218	269
50. General industrial machinery	13	138	150	72	778	850
51. Special industrial machinery	9	104	114	88	981	1,068
52. Other general machines	40	136	177	91	309	400
53. Office machines & machinery for service industry	13	68	81	36	197	234
54. Household electric appliance	4	81	85	33	595	628
55. Electric & communication equipment	14	65	79	254	1,223	1,477
56. Heavy electrical equipment	10	99	110	43	410	453
57. Other electrical equipment	17	113	130	35	229	264
58. Motor vehicles	12	112	123	214	2,036	2,250
59. Ships & its repair	38	138	175	57	208	265
60. Other transport equipment & its repair	18	90	109	22	109	131
61. Scientific instruments	14	71	84	41	209	250
62. Miscellaneous manufacturing products	17	81	99	54	253	307
63. Construction	329	166	495	26,302	13,291	39,592
64. Water supply & sewage	608	115	722	1,261	238	1,499
65. Waste disposal services	0	29	29	0	39	39
66. Wholesale trade & retail trade	12	16	28	815	1,070	1,885
67. Financial service & insurance	0	13	13	1	112	113
68. Real estate rental service	10	18	28	7	12	19
69. House rent	0	21	21	0	1,134	1,134
70. Railway transport	42	47	88	146	164	310
71. Road transport	2	14	17	22	129	150
72. Ocean transport & coastal transport	0	18	18	1	42	43
73. Air transport	0	21	21	1	33	34
74. Storage facility service	16	35	52	8	17	24
75. Services relating to transport	1	42	42	2	137	139
76. Telecommunication	0	15	16	2	70	72
77. Broadcasting	2	27	30	2	20	22
78. Education	2	25	27	51	548	599
79. Research	4	33	37	3	28	31
80. Medical service, health & hygiene	4	41	44	127	1,430	1,558
81. Other public services	2	22	24	6	79	85
82. Advertising services	0	44	45	0	5	5
83. Information services	0	16	16	0	59	59
84. Goods rental & leasing	1	14	14	1	22	23
85. Repair of motor vehicles and machine	12	59	71	72	341	413
86. Other business services	3	14	17	22	90	112
87. Amusement and recreation services	3	31	34	38	376	414
88. Eating and drinking place	3	40	43	63	927	991
89. Hotel and other lodging places	4	38	42	26	266	292
90. Other personal services	22	27	48	199	252	451
91. Activities not elsewhere classified	30	43	72	1	2	3
92. Office supplies	0	31	31	8	787	795

Appendix E: Construction sector classifications (24 sector)

1. Residential & non-residential construction	1. Residential construction 2. Residential construction (wooden) 3. Residential construction (non-wooden) 4. Non-residential construction 5. Non-residential construction (wooden) 6. Non-residential construction (non-wooden)
2. Civil engineering	7. Riparian work 8. Drainage work 9. General road construction 10. Toll road construction 11. Land readjustment work 12. Harbor & fishing port construction 13. Airport construction 14. Environmental sanitation work 15. Park construction 16. Repair work after disaster 17. Agricultural public construction 18. Other civil engineering and construction 19. Railway construction 20. Electric power facilities construction 21. Telecommunication facilities construction 22. Construction for water supply 23. Land development 24. Other civil engineering

Table 3: Contributions of final demand to the embodied waste generations (thousand tons)

Industrial wastes	F_{hoe}	F_{hie}	F_{hni}	F_{gov}	F_{pub}	F_{pri}	F_{adi}	F_{exp}	F_{etc}	Total
1.Waste active carbon · waste carbon	0	2	0	0	0	0	0	1	0	4
2.Unclassified incineration ash	88	1,170	14	176	124	311	21	283	3	2,190
3.Sewerage sludge	3,012	44,348	603	17,392	1,665	4,133	96	2,856	712	74,816
4.Other organic sludge	2,011	20,846	322	3,521	2,199	5,303	218	5,012	3,646	43,078
5.Construction sludge	41	1,001	11	238	7,293	10,006	6	121	26	18,744
6.Waterworks sludge	316	4,647	63	1,823	176	435	10	300	75	7,844
7.Other inorganic sludge	920	12,299	184	2,530	16,968	27,701	557	10,390	246	71,795
8.Mineral oil	8	102	1	15	13	53	1	40	10	242
9.Oils and fats of animals and plants	40	108	0	9	2	7	0	4	1	172
10.Benzine	1	12	1	7	2	5	0	6	1	35
11.Unclassified general waste fluid	56	670	8	92	103	364	10	308	51	1,663
12.Waste solvents	10	135	5	55	26	84	4	115	10	445
13.Solid oil	1	9	0	2	6	14	0	12	1	45
14.Oil mud	4	59	1	12	8	24	1	22	7	138
15.Clothes including oil	0	3	0	1	1	2	0	2	0	9
16.Inorganic acid waste fluid	90	862	9	139	237	727	22	724	45	2,855
17.Waste fluid from photographic fixing	5	77	1	17	44	142	5	124	7	422
18.Corrosive waste fluid	4	22	0	1	0	1	0	3	0	31
19.Strong acid waste fluid	2	27	1	7	10	31	1	28	2	110
20.Alkaline waste fluid	29	368	13	142	62	206	9	249	24	1,104
21.Developing solution of photograph	2	38	1	9	14	49	2	41	2	158
22.Strong alkaline waste fluid	1	7	0	2	1	4	0	7	0	23
23.Synthetic fiber	84	1,283	17	191	677	1,321	20	542	85	4,219
24.Fiber reinforced plastic	0	5	0	1	1	5	0	6	0	19
25.Plastics plasticized by high heat	7	76	1	14	12	33	3	29	13	189
26.Resins reinforced high heat	2	25	0	4	5	14	0	11	4	67
27.General scrap plastics	35	354	6	69	75	191	3	85	31	849
28.Synthetic rubber	0	4	0	1	1	3	0	4	1	15
29.Agricultural plastic wastes	0	0	0	0	0	0	0	0	0	0
30.Waste tires	34	530	4	49	67	207	3	76	31	1,002
31.Waste papers	89	840	18	177	80	224	9	161	173	1,771
32.Wood chips	74	832	13	155	1,925	2,838	17	170	86	6,110
33.Waste fiber	3	96	1	5	3	12	0	10	1	132
34.Waste residuals of animals	6	90	0	4	0	0	0	2	0	102
35.Waste residuals of plants	28	180	1	13	1	2	−1	5	0	230
36.Unclassified waste residuals of animals and plants	134	1,319	3	72	2	7	−5	16	0	1,548
37.Waste rubber	1	17	0	35	4	11	0	11	2	81
38.Waste metal	100	1,403	14	180	697	1,462	19	526	101	4,503
39.Waste glasses	34	264	6	61	50	107	1	47	11	580
40.Waste ceramics	11	102	1	16	89	142	1	27	4	394
41.Plaster board	16	154	2	28	417	630	9	133	9	1,398
42.Asbestos etc.	0	3	0	0	1	1	0	0	0	6
43.Unclassified waste glass and ceramics	28	350	9	112	961	1,381	8	138	15	3,003
44.Waste sand	41	676	5	102	640	1,673	37	1,395	73	4,641
45.Blast furnace slag	6	85	1	12	69	172	5	146	10	505
46.Slag	20	366	3	58	399	875	32	598	53	2,404
47.Unclassified slag	50	893	7	143	1,090	2,489	50	1,651	83	6,457
48.Waste concrete	53	1,286	14	283	7,774	10,734	11	251	43	20,449
49.Waste asphalt	41	1,010	12	240	7,267	9,973	6	125	27	18,699
50.Other construction wastes	34	913	8	164	3,424	4,774	7	183	32	9,539
51.General waste particles	162	3,182	34	542	683	1,701	44	1,431	149	7,929
52.Solid concrete wastes	0	0	0	0	0	0	0	0	0	0
53.Dung and urine of animals	0	0	0	0	0	0	0	0	0	0
54.Animal corpse	0	0	0	0	0	0	0	0	0	0
55.Shredder dust	0	0	0	0	0	0	0	0	0	0
56.Unclassified wastes	4	65	1	15	9	24	0	9	3	132
57.Melting wastes	0	0	0	0	0	0	0	0	0	0
Total	7,741	103,217	1,420	28,939	55,378	90,608	1,244	28,437	5,909	322,894

Note: The results exclude hazardous wastes. F_{hoe} is the consumption expenditure outside households, F_{hie} is the consumption expenditure of households, F_{hni} is the consumption expenditure of private non-profit institutions, F_{gov} is the consumption expenditure of central and local governments, F_{pub} is the gross domestic fixed capital formation (public), F_{pri} is the gross domestic fixed capital formation (private), F_{adj} is the increase in stocks, F_{exp} is the exports, and F_{etc} is the other final demand.

Table 4: Contributions of final demand to the embodied landfill quantities (thousand tons)

Industrial wastes	F_{hoe}	F_{hie}	F_{hni}	F_{gov}	F_{pub}	F_{pri}	F_{adi}	F_{exp}	F_{etc}	Total
1.Waste active carbon · waste carbon	0	1	0	0	0	0	0	1	0	2
2.Unclassified incineration ash	22	370	5	70	52	129	4	88	26	767
3.Sewerage sludge	82	1,206	17	475	45	113	3	78	19	2,036
4.Other organic sludge	123	1,434	20	229	208	455	13	366	201	3,050
5.Construction sludge	22	537	6	128	3,909	5,363	3	65	14	10,047
6.Waterworks sludge	30	437	6	171	17	41	1	28	7	738
7.Other inorganic sludge	215	3,257	48	647	3,761	6,384	185	2,930	253	17,680
8.Mineral oil	0	3	0	0	0	2	0	2	0	8
9.Oils and fats of animals and plants	1	2	0	0	0	0	0	0	0	3
10.Benzine	0	1	0	0	0	0	0	0	0	2
11.Unclassified general waste fluid	1	12	0	3	2	7	0	6	1	31
12.Waste solvents	0	4	0	1	1	2	0	3	0	13
13.Solid oil	0	5	0	1	1	2	0	3	0	13
14.Oil mud	0	1	0	0	0	1	0	1	0	3
15.Clothes including oil	0	0	0	0	0	0	0	0	0	1
16.Inorganic acid waste fluid	58	429	2	45	5	14	−2	21	2	574
17.Waste fluid from photographic fixing	0	3	0	1	2	6	0	5	0	16
18.Corrosive waste fluid	3	17	0	0	0	0	0	0	0	20
19.Strong acid waste fluid	0	0	0	0	0	0	0	0	0	1
20.Alkaline waste fluid	2	26	1	12	6	17	1	17	2	84
21.Developing solution of photograph	0	4	0	1	1	3	0	2	0	11
22.Strong alkaline waste fluid	0	0	0	0	0	0	0	0	0	1
23.Synthetic fiber	53	832	10	131	541	1,019	14	375	54	3,029
24.Fiber reinforced plastic	0	4	0	1	1	4	0	5	0	16
25.Plastics plasticized by high heat	2	27	0	4	5	13	2	12	2	69
26.Resins reinforced high heat	1	9	0	1	2	7	0	6	1	27
27.General scrap plastics	13	108	2	21	24	55	1	27	10	261
28.Synthetic rubber	0	3	0	0	1	2	0	3	1	10
29.Agricultural plastic wastes	0	0	0	0	0	0	0	0	0	0
30.Waste tires	4	70	0	5	6	21	0	11	4	124
31.Waste papers	9	91	2	20	11	28	1	20	19	201
32.Wood chips	5	73	1	15	323	454	1	12	5	889
33.Waste fiber	1	35	0	2	1	4	0	3	0	48
34.Waste residuals of animals	0	3	0	1	0	0	0	0	0	5
35.Waste residuals of plants	1	10	0	2	0	0	0	1	0	14
36.Unclassified waste residuals of animals and plants	21	219	0	11	0	1	−1	3	0	254
37.Waste rubber	1	11	0	4	3	8	0	7	1	35
38.Waste metal	28	319	6	59	285	472	3	93	19	1,283
39.Waste glasses	20	151	2	19	35	69	1	21	6	322
40.Waste ceramics	6	61	1	12	39	65	1	17	3	206
41.Plaster board	8	87	1	16	229	345	4	68	5	761
42.Asbestos etc.	0	3	0	0	1	1	0	0	0	6
43.Unclassified waste glass and ceramics	19	234	8	92	759	1,084	5	94	10	2,304
44.Waste sand	5	108	1	17	63	216	5	145	10	570
45.Blast furnace slag	2	26	0	2	6	18	1	13	2	70
46.Slag	10	175	2	31	121	318	19	263	39	978
47.Unclassified slag	30	507	4	87	640	1,455	30	953	50	3,756
48.Waste concrete	21	498	5	105	2,630	3,668	6	153	20	7,107
49.Waste asphalt	7	178	2	41	1,226	1,683	1	22	5	3,165
50.Other construction wastes	19	447	5	88	2,003	2,801	4	132	23	5,523
51.General waste particles	79	1,599	18	278	215	546	15	425	62	3,238
52.Solid concrete wastes	0	0	0	0	0	0	0	0	0	0
53.Dung and urine of animals	0	0	0	0	0	0	0	0	0	0
54.Animal corpse	0	0	0	0	0	0	0	0	0	0
55.Shredder dust	0	0	0	0	0	0	0	0	0	0
56.Unclassified wastes	3	39	1	10	6	16	0	6	2	83
57.Melting wastes	0	0	0	0	0	0	0	0	0	0
Total	929	13,675	178	2,861	17,185	26,914	324	6,508	879	69,454

Note: The results exclude hazardous wastes. According to the official report of the former MHW, the total final disposal quantity in 1995 is about 69,000 (thousand ton).