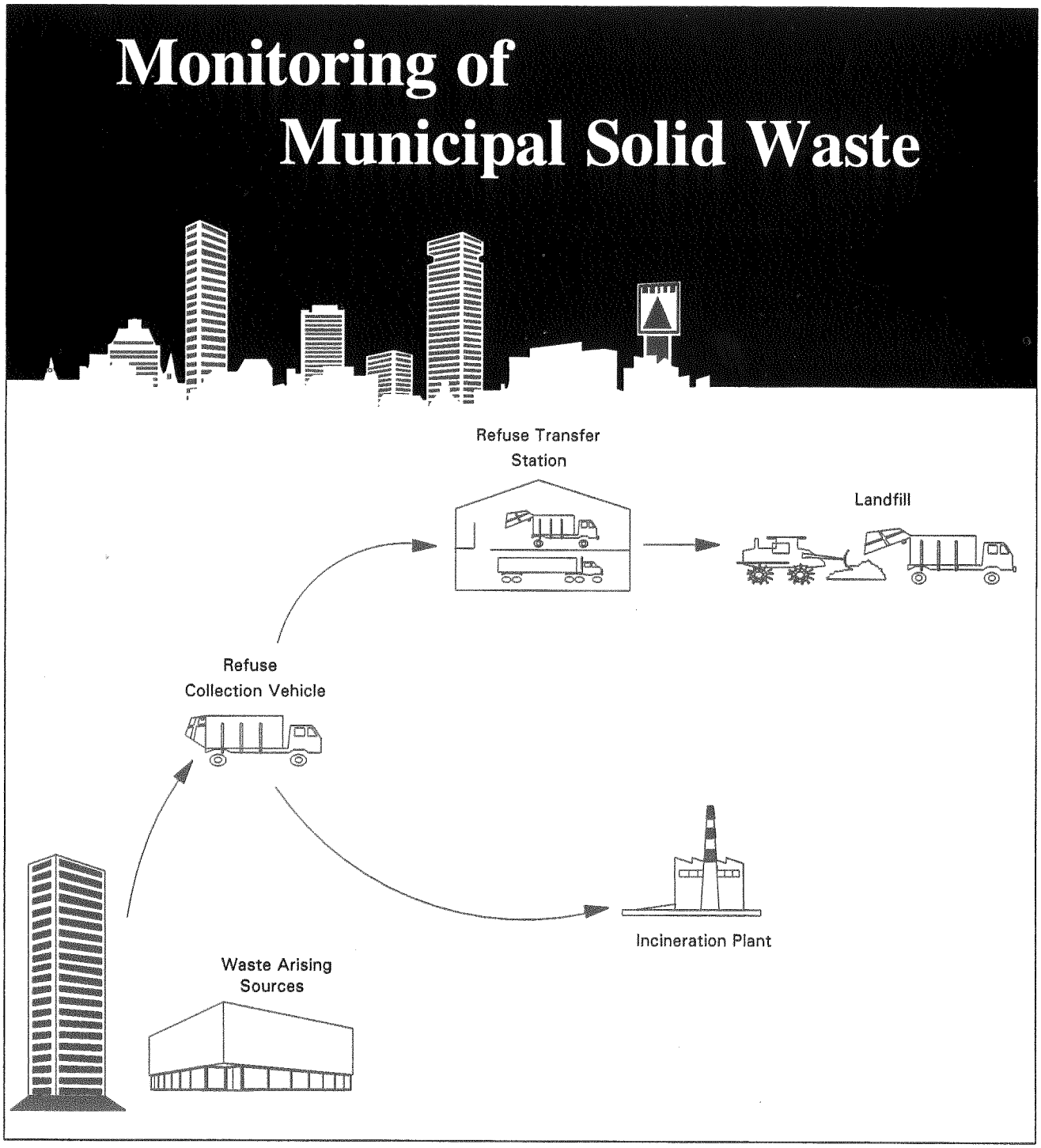
Monitoring of Municipal Solid Waste



Environmental Protection Department

1991
1992

Monitoring of Municipal Solid Waste 1991-1992

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Abstract

This is the tenth report on the monitoring of municipal solid waste arisings. This report presents the results of the waste arisings surveys conducted in 1991 and 1992, identifies the quantities, classifications and characteristics of municipal solid waste and other/special waste arisings in 1991 and 1992, examines the historic growth in waste quantity and its relationship with relevant socio-economic indicators, and produces forecasts of future waste arisings by geographical districts and waste types for the year 1993 and the quinquennial planning years 1996, 2001 and 2006.

SUMMARY OF FINDINGS

1. The average daily quantities of municipal solid waste delivered to landfills for disposal in 1991 and 1992 were respectively 23,763 and 19,896 tonnes, representing an increase of 53% in 1991 and a drop of 16% in 1992 over the respective preceding years. The breakdown into domestic, commercial, industrial and construction wastes was 5560, 397, 1431 and 16375 tonnes per day respectively in 1991 and 5761, 460, 1713 and 11962 tonnes per day respectively in 1992. Domestic waste arisings continued to increase steadily in both years due to the growth in population and the increasing per capita waste generation rate. For total commercial & industrial wastes, increases of 11% and 19% were observed in 1991 and 1992 respectively. Following a sharp increase in 1991, especially for the HK Island region, the quantity of construction waste in 1992 reduced considerably for both the HK Island and Kowloon regions.

2. The proportions of most major waste components have remained fairly constant over the past few years. One exception is putrescibles in domestic waste which have reduced by 7%, whilst their content in commercial & industrial waste has increased by 10% in 1991. The rags content of the commercial & industrial wastes reduced in 1991 by 11% as compared to the previous year level before 1990. The minority constituents still remain constant at the previous year level. The compositions of domestic waste from the Urban Area and from the New Territories remained very similar. As for commercial & industrial waste, the surveys revealed some inconsistent fluctuations. Putrescible content in the domestic and commercial & industrial waste from the New Territories remained higher than that from the Urban Area whilst plastic content in the same from the Urban Area was higher. Similar to previous observations, the moisture content of domestic waste is much higher than that of commercial & industrial waste. The average bulk waste densities in 1991 recorded fluctuations over 1990 accompanied with a significant increase of 47% in the density of domestic waste, a 15% drop in the density of commercial waste and a 12% increase in the density of industrial waste. In 1992, the density of domestic waste dropped by 17% whilst the density of commercial and industrial wastes increased by 44% & 13% respectively. Field observations indicated that about a quarter of the construction waste received at landfill would be suitable without further processing for disposal at public dumping sites and that recyclable paper and plastic constituted more than 20% of either domestic or commercial & industrial waste received at landfills. Compared with other developed cities and countries, Hong Kong's municipal solid waste may be characterised as being relatively low in the content of paper, metal and glass but relatively high in that of plastics and other miscellaneous constituents.

3. The territorial average generation rates for domestic waste in 1991 and 1992 are respectively 0.98 and 1.01kg per capita per day, while those for commercial & industrial waste in 1991 and 1992 are respectively 1.09 and 1.29kg per employee per day. The generation rates for domestic waste in the Urban Area are higher than those in the New Territories whilst the generation rates for commercial & industrial waste in the New Territories still remain as much as double of those in the Urban Area and vary significantly from district to district.

4. Based on the historical trends of the waste generation rates, the projected arisings of domestic and commercial & industrial wastes will reach 9,520 and 3,410 tonnes per day respectively in 2006. By including the public dumping waste and excavated/dredged waste dumped at the gazetted marine spoil grounds, the construction waste arising in 2006 is expected to reach 26,825 tonnes per day. It is forecasted that the total quantity of municipal solid waste including construction waste as redefined above will then become 39,755 tonnes per day in 2006 with 67% being construction waste. In establishing the correlation between waste arisings and the GDP figures, only domestic, commercial and industrial wastes have been considered in this report. The projection of future waste arisings based on this correlation agrees very well with that obtained above.

List of Contents

List of Figures

List of Appendices

1. INTRODUCTION

Background

1.1 This is the tenth in a series of reports on the surveys of waste arisings in Hong Kong. The monitoring of waste arisings started in 1981 with a view to establishing a database for waste management planning. The detailed objectives of the programme are listed in Appendix I.

1.2 This report presents the results of the surveys carried out by EPD in 1991 and 1992. The presentation generally follows the formats of previous reports but with updated figures and information on waste composition, quantities and distribution. With this information added to the database, the historical growth in waste quantity and its relationship with socio-economic indicators are again examined. The forecasts of future waste arisings are then reviewed and revised.

Waste Classification System and Terminology

1.3 For the purposes of this report, the system of waste classification as shown in Figure 1 is adopted. This classification is, to a large extent, dictated by the current institutional arrangements for the collection and disposal of waste. A detailed description of the major classes of waste is given below. For the sake of simplicity, the names of the government departments concerned in the waste management system are abbreviated and their full names are given in Appendix II.

Domestic/Public Cleansing Waste

Domestic/public cleansing waste covers mainly household waste and refuse collected in public cleansing activities. Household waste refers to waste generated from residential premises in the course of normal daily activities. Refuse collected in public cleansing activities is dirt and litter collected from street cleansing and litter bins by USD and RSD, marine collection waste by MD, and litter from beaches and country parks. Also, some commercial/ trade wastes are intermixed with these wastes in the Refuse Collection Points, particularly those in the urban area and in the business districts with interfaces of residential and commercial premises. The waste is disposed of at the municipal waste incinerators and the landfills with the majority of waste being delivered to the landfills. Quantitative data are available for the following components of Domestic and Public Cleansing waste -

- Household/street wastes
  This is mainly household waste (excluding bulky items) and refuse collected in public cleansing activities. The inseparable portion of commercial/trade waste is also grouped under this heading. During the survey, the sources of wastes are identified by interviewing the drivers of refuse delivery vehicles.

- Bulky waste
  This refers to discarded furniture and domestic appliances of household origin which cannot be handled by the conventional refuse collection vehicles. They are separately collected and therefore can be easily identified at the disposal sites.

Quantity (tonnes/day) Description of Waste Type	1991 Collection Agency Public	1991 Collection Agency Private	1991 Total	1992 Collection Agency Public	1992 Collection Agency Private	1992 Total
1. Domestic/Public Cleansing						
-household/street waste	4,321	857	5,178	4,386	834	5,220
-junk and bulky	255	65	320	382	105	487
-marine collection	17	-	17	16	-	16
-beaches	35	-	35	29	-	29
-country parks	10	-	10	9	-	9
		Sub-total	5,560 (+2%)		Sub-total	5,761 (+4%)
2. Commercial						
-commercial mixed	-	331	331	-	360	360
-junk	-	32	32	-	54	54
-markets	-	11	11	-	26	26
-paper	-	23	23	-	20	20
		Sub-total	397 (+14%)		Sub-total	460 (+16%)
3. Industrial						
-manufacturing mixed	-	1,221	1,221	-	1,472	1,472
-plastic	-	22	22	-	29	29
-wood/sawdust	-	119	119	-	142	142
-rags	-	21	21	-	27	27
-glass	-	19	19	-	18	18
-rubber	-	-	-	-	-	-
-tannery	-	11	11	-	4	4
-paper		18	18	-	21	21
		Sub-total	1,431 (+10%)		Sub-total	1,713 (+20%)
4. Construction (landfilled)						
-mixed/site clearance	-	8,552	8,552	-	5,526	5,526
-soft material/rubble	-	7653	7,653	-	5,940	5,940
-wood/bamboo	-	170	170	-	496	496
		Sub-total	16,375 (+94%)		Sub-total	11,962 (-27%)
Total of Municipal Solid Waste delivered for disposal(1 to 4)	4,638	19,125	23,763 (+53%)	4,822	15,074	19,896 (-16%)
5. Special waste	11	327	338	61	259	320
6. Export of recovered waste materials			3,500			3,898
Total(1 to 6)			27,601 (+43%)			24,114 (-13%)

Public - Waste collected by USD and RSD
Private - Waste collected by private contractor or other government departments
(±%) - % increase/decrease over previous year

Figure 1 Waste Types as Classified in the Monitoring Programme and Their Arisings in 1991 and 1992

- Marine waste
  This is mainly floating refuse scavenged by the MD during their harbour cleansing activities. It also includes waste collected from ocean going vessels moored in the harbour and dwelling boats in typhoon shelters. MD maintains a record of the quantities collected.

- Beach litter
  USD and RSD maintain their own records of the quantities collected.

- Country park litter
  A&FD maintains a record of the quantity collected.

Commercial Waste

Commercial waste is waste arising from all forms of commercial activity such as markets, shops, restaurants, hotels and offices, but not factories. It is collected mainly by private contractors although, as mentioned earlier, a small portion is collected by USD and RSD. The remaining portion is collected by the private sector and is largely disposed of at landfills with a limited quantity being delivered to the incinerators. That part collected by USD and RSD is disposed of in the same manner as for domestic waste.

Industrial Waste

Industrial waste is waste arising from any industrial activity. It includes solid wastes from all manufacturing industries but excludes chemical waste and waste from the construction industry. Collection and transportation of this waste is carried out either by private contractors or by direct labour from the industries themselves. This waste is disposed of at the landfills.

Construction Waste

Construction waste is waste arising from any land excavation or formation, civil/building construction, roadwork, building renovation or demolition activities. It includes various types of building debris, rubble, earth, concrete, timber and mixed site clearance materials but for the purpose of this report, excludes materials disposed of at public dumps, reclamations or marine spoil grounds. Collection and disposal of construction waste is carried out entirely by the private sector and all disposal is to landfills.

Municipal Solid Waste

For the purpose of this report, municipal solid waste is defined as the aggregates of domestic/public cleansing waste, commercial waste and industrial waste. This grouping together with construction waste (defined as above) represent the majority of solid waste disposed of at the municipal waste incinerators and landfills.

Public Dumping Waste

Public dumping waste arises from the same sources as construction waste but is disposed of at public dumps. Any person delivering waste to public dumps needs to have a valid dumping licence and to comply with the licence conditions. In anticipation of the Construction Waste New Disposal Arrangements, the relaxation of Public Dumping Licence Conditions has been implemented since October 1992 to accept earth, building debris and stone of any size that are free of any organic waste and floatable matters.

Marine Dumping Waste

This comprises dredged and excavated wastes dumped at the gazetted marine spoil grounds. Dredged waste is produced as a result of dredging activity in the harbour, in rivers, in nullahs or along the waterfront area. Excavated waste is mainly soil and rock excavated during large scale civil engineering works.

Outline of the Surveys

1.4 Two surveys, covering both the wet and dry seasons were carried out by EPD in each of the years 1991 and 1992. The field work was carried out around June/July and November /December in each year. During each survey, all operating landfills, incinerators and refuse transfer stations were visited one by one. The major tasks involved were -

Weighbridge Monitoring

This refers to the collection of information about the refuse delivered by vehicles arriving at the weighbridges of each visited disposal facility. The information collected on each incoming vehicle includes arrival time of vehicle, vehicle registration number and ownership, waste type and quantity, and source of the waste. All the information except the waste quantity was obtained by interviewing the vehicle drivers. A typical form used for logging this information is attached at Appendix III.

Refuse Sorting

Refuse samples for sorting were collected each day from at least 5 Refuse Collection Vehicles (RCVs). The vehicles were selected in such a way that they contained a good balance of major waste types including domestic, commercial and industrial wastes. Each sample, of 1 m^3 in volume, was sorted by waste type and weighed in order to determine its composition and bulk density. The moisture content of 1-2 kg of a refuse sample was determined.

Since construction waste is too bulky for hand sorting, its composition was determined by observation only. Two staff stayed at the tipping face throughout normal working hours and recorded independently, based on each own judgement, the percentage by volume of the various components of each load of construction waste. The composition of construction waste was then approximated by averaging the two results so obtained. Where two records for a particular waste load differed significantly, they were discarded and replaced by another set of records of observation.

2. WASTE QUANTITIES

Municipal Solid Waste

2.1 CED and EMSD maintained records of the quantities, as measured by weighbridges, of all wastes received at their disposal facilities throughout the year. Data for the following classifications of waste were extracted from these records and used as the control totals -

- Domestic/public cleansing, commercial and industrial wastes collected by USD and RSD.
- Domestic/public cleansing, commercial and industrial wastes collected by parties other than USD and RSD.
- Construction waste.

The quantities for other sub-classes of waste shown in Figure 1 were derived from their relative proportions as determined by the surveys. Data for marine collection waste, beach litter, country park litter and export quantity of recovered materials are however provided by the Marine Department, USD/RSD, A&FD and C&SD respectively.

Other/Special Wastes

2.2 In addition to municipal solid waste, there are a number of other waste types produced in Hong Kong. Their 1991 and 1992 average daily arisings are shown in Figure 2. This information is obtained or estimated in the following manner -

- Quantity of public dumping materials is obtained from monthly records provided by Public Dump Contractors, which reflect the daily disposal quantity at all government reclamation sites. Materials deposited in private reclamation projects have not been included.
- Quantity of marine dumping is the actual quantity of excavated material disposed of by marine dumping with EPD's approval in each year.
- Quantity of waterworks sludge and sewage sludge and sewage works screening is extracted from Integrated Sludge Disposal Strategy Interim Report Dec. 1991.
- Quantity of excremental waste is derived from the proportion collected by USD and RSD which are assumed to have handled 95% of the territory's total excremental waste.
- Quantity of livestock waste is estimated from the number and sizes of operational livestock farms.
- Quantity of abattoir waste is estimated from the number of live animals slaughtered at abattoirs and disposed of at landfills or by-product plants in each year.
- Quantity of animal carcasses is actually the number of dead animals collected by USD, RSD and A&FD which constitutes the majority of animal carcasses arising in the territory.
- Quantities of high security waste in 1991 and 1992 were extracted from the Centralised Incineration Facility For Special Waste - Phase 1 Feasibility Report 1992.
- Quantity of condemned goods disposed of at landfills has been monitored by EPD since late 1990. Information is extracted from the permit applications for disposal of trade waste at the landfills. The 1991 and 1992 arisings shown are the average daily quantity since records have been kept.

Description of Waste	Quantity per day				
	Units	1989	1990	1991	1992
Public dumping materials for land reclamation purposes	cu.m	7,100	3,700	2,700	7,315
Marine dumping/Dredged & excavated marine spoil	cu.m	35,000	17,500	95,500	167,200
Semi-solid waste					
- water works sludge (1)	tonnes	3,580	3,720	3,630	3,770
- sewage sludge (2)	tonnes	200	200	280	330
- sewage works screening	tonnes	40	40	40	40
- excremental waste (3)	tonnes	80	140	150	160
- livestock waste	tonnes	1,400	1,100	1,600	1,200
Sub-total :	tonnes	5,300	5,200	5,700	5,500
		(-7%)	(-2%)	(+10%)	(-4%)
Special waste					
- abattoir waste	tonnes	32	30	30	11
- animal carcasses	tonnes	7	5	7	7
- condemned goods	tonnes	5	5	5	5
- high security waste	tonnes	10	12	9	9
- clinical waste	tonnes	20	20	23	23
Sub-total :	tonnes	74	72	74	55
		(+12%)	(-3%)	(+3%)	(-26%)
Chemical waste	tonnes	290	300	250	323
Coal ash					
- pulverised fuel ash	tonnes	2,700	2,900	2,900	2,700
- furnace bottom ash	tonnes	400	400	400	300
Sub-total :	tonnes	3,100	3,300	3,300	3,000
		(+3%)	(+6%)	(0 %)	(-9%)
Secondary waste					
- incinerator ash	tonnes	450	350	330	315
- pulverised rejects	tonnes	390	380	-	-
Sub-total :	tonnes	840	730	330	315
		(-1%)	(-13%)	(-55 %)	(-5%)

Remarks : 1. with average 2.5% dry solid
2. with average 15% dry solid
3. assumed bulk density at 1.2 tonnes/cu.m.
(± %) - % increase/decrease over previous year

Figure 2 Estimated Arising of Wastes Other Than Municipal Solid Waste

- Quantities of clinical waste in 1991 and 1992 were obtained from the estimations as provided in the Centralised Incineration Facility For Special Waste - Phase 1 Feasibility Report 1992.

- Quantity of chemical waste arisings in 1991 was extracted from the forecast as provided in the survey carried out by consultants. The quantities shown for 1992 was obtained from the survey carried out by Solid Waste Control Group of Environmental Protection Department.

- Quantities of pulverised fuel ash and furnace bottom ash are obtained from the monitoring records of the two power companies.

- Quantities of incineration ash are provided by EMSD based on the weighbridge records of their incineration plants.

- Quantities of pulverised rejects are deleted as a result of the decommissioning of the pulverization plant.

2.3 The above waste types are specifically identified for one or more of the following reasons-

- The waste arisings are relatively large in quantity and any change of the disposal method would have a considerable effect on the waste management system.

- They may be delivered to the landfills for disposal and hence affect the remaining capacity of such disposal facilities.

- They all require special handling during storage, transportation and disposal and may cause public health hazards if not properly managed.

- They may have the potential for recycling and re-use which would reduce the burden on waste collection and disposal services.

Geographical Distribution

2.4 For the purpose of monitoring the source distribution of waste, the whole territory is divided into 19 Waste Arisings Districts (WAD), subdivided into 53 Waste Arisings Areas (WAA). The boundaries of the WADs are generally in accordance with the District Board boundaries and the areas covered by the WAAs are aggregates of tertiary planning units with similar socio-economic characteristics. The distribution of municipal solid waste arisings in 1991 and 1992 by district and by region are shown in Figures 3 and 5 and the quantities as delivered to incineration plants, refuse transfer stations and landfills are depicted in Figure 6 with a detailed breakdown provided in Appendix IV.

Compared to the 1990 quantities, the major points of interest are as follows -

- The total quantity of municipal solid waste increased by 53% in 1991. The significant increase in 1991 was mainly due to the greatest increase in construction waste disposed of at landfills in a single year because of insufficient conveniently located public dumps. In 1992, the Hung Hom Bay Public Dump was opened in the Urban Area. As a result, the construction waste disposed of at landfills dropped by 27% and led to a reduction of 16% in the total quantity of municipal solid waste in 1992 over the previous year.

- Domestic waste arisings continued to increase steadily in both years due to the continuous growth in population and the increasing per capita waste generation rate.

District	Waste Quantities in Tonnes per Day									
	1991					1992				
	Domestic Waste		Commercial & Industrial Waste	Construction Waste (Landfilled)	Municipal Solid Waste	Domestic Waste		Commercial & Industrial Waste	Construction Waste (Landfilled)	Municipal Solid Waste
	Publicly Collected (a)	Privately Collected (b)	(c)	(d)	(a+b+c+d)	Publicly Collected (a)	Privately Collected (b)	(c)	(d)	(a+b+c+d)
Central & Western	338	45	59	1,538	1,980	343	62	82	539	1,026
Wanchai	242	83	35	914	1,274	242	94	53	575	964
Eastern	384	137	100	1,050	1,671	407	164	144	591	1,306
Southern	203	18	57	660	938	217	24	45	446	732
HK ISLAND	1,167 (+3%)	283 (+15%)	251 (+21%)	4,162 (+265%)	5,863 (+114%)	1,209 (+4%)	344 (+22%)	324 (+29%)	2,151 (-48%)	4,028 (-31%)
Yau Ma Tai	274	58	118	372	822	291	81	104	300	776
Mong Kok	165	51	24	444	684	155	60	41	332	588
Sham Shui Po	323	49	111	1,175	1,658	283	41	123	485	932
Kowloon City	301	69	105	705	1,180	316	88	154	502	1,060
Wong Tai Sin	240	14	65	443	762	264	22	87	441	814
Kwun Tong	407	187	288	2,197	3,079	397	36	357	915	1,705
KOWLOON	1,710 (-3%)	428 (-10%)	711 (+7%)	5,336 (+50%)	8,185 (+26%)	1,706 (0%)	328 (-23%)	866 (+22%)	2,975 (-44%)	5,875 (-28%)
Kwai Chung	304	30	184	950	1,468	295	20	172	628	1,115
Tsuen Wan	137	60	260	1,400	1,857	180	80	271	1,216	1,747
Tuen Mun	253	26	120	923	1,322	322	30	117	1,614	2,083
Yuen Long	191	21	107	385	704	207	11	143	150	511
North	153	8	28	417	606	155	12	19	335	521
Tai Po	154	20	52	669	895	156	42	96	1,193	1,487
Shatin	366	40	92	1,717	2,215	382	55	117	1,241	1,795
Sai Kung	101	6	23	416	546	91	18	47	459	615
NEW TERRITORIES	1,659 (+7%)	211 (+4%)	866 (+11%)	6,877 (+84%)	9,613 (+53%)	1,788 (+7%)	268 (+26%)	982 (+14%)	6,836 (0%)	9,874 (+3%)
OUTLYING ISLANDS	102 (+31%)	-	-	-	102 (+31%)	119 (+25%)	-	-	-	119 (-6%)
TERRITORIAL TOTAL	4,638 (+3%)	922 (0%)	1,828 (+11%)	16,375 (+94%)	23,763 (+53%)	4,822 (+4%)	940 (+2%)	2,172 (+19%)	11,962 (-27%)	19,896 (-16%)

Remarks : Special wastes excluded
(±%) - % increase/decrease over the previous year

Figure 3 Distribution of Municipal Solid Waste Arisings by District

- The commercial and industrial waste had increased by 11% and 19% in 1991 and 1992 respectively.

- Following an increase in 1990, the quantities of construction waste in 1991 further increased significantly by 94%, especially for the HK Island region (+265%). In 1992, the sharp drop in construction waste for HK Island and Kowloon regions resulted in a reduction of 27% in the total quantity of construction waste over the pervious year.

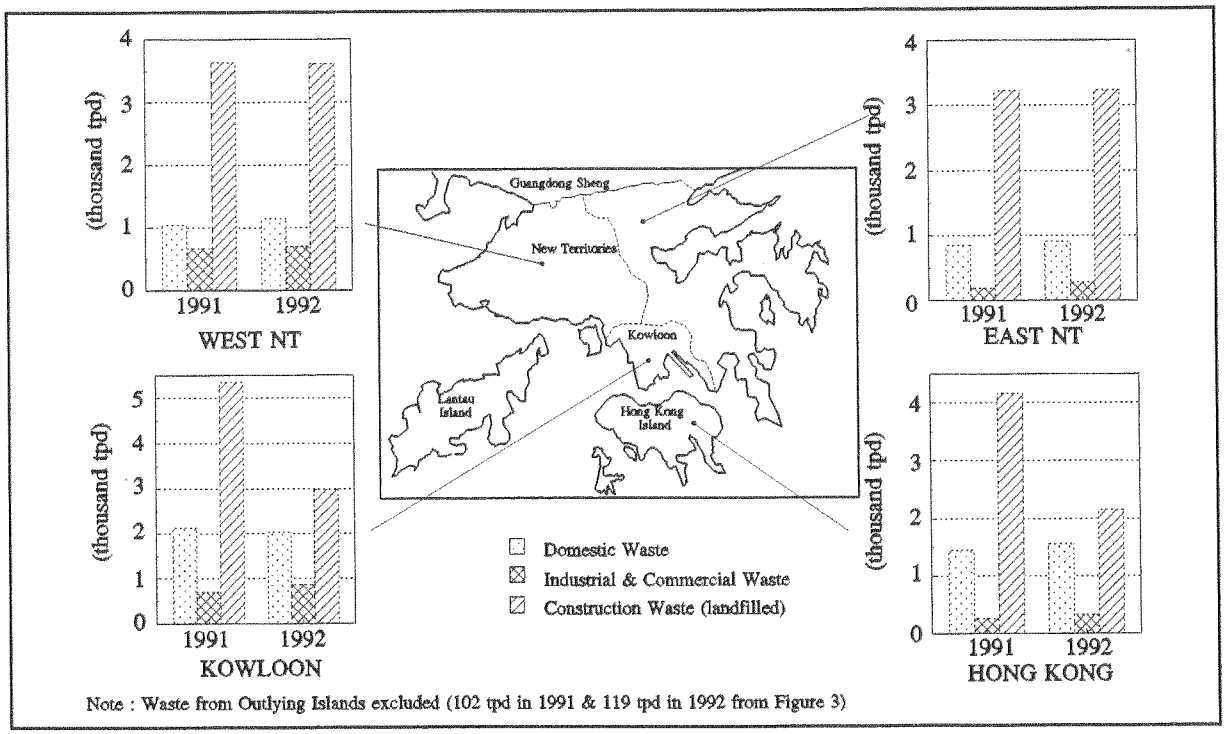
Island	Quantity (tpd)	
	1991	1992
Cheung Chau	47	53
Mui Wo	23	26
Discovery Bay	9	11
Yung Shue Wan	10	12
Sok Kwu Wan	2	2
Peng Chau	9	10
Hei Ling Chau	2	5
Total	102	119

Figure 4 Municipal Solid Waste Arisings on the Major Outlying Islands

Export of Materials Recovered from Waste

2.5 Waste recycling/recovery activities continued to play a significant part in the waste disposal system in 1991 and 1992. The quantities and values of waste materials recovered for export in 1991 and 1992 are shown in Appendix V. The major types of materials recovered and exported are paper, paperboard,ferrous and non-ferrous metals, and plastics. Compared to the 1990 quantities, there was an increasing trend for the export of most materials in quantity, except paper, the exported quantity of which increased in 1991 followed by a drop in 1992. Export of plastic waste has been increasing rapidly and consistently for a few years. Further increases of 43% and 67% were noted in 1991 and 1992 respectively.

2.6 These figures have been closely monitored as any significant drop in the export amount of major recovered wastes would result in a corresponding increase in the demand for disposal capacity in Hong Kong.



Note : Waste from Outlying Islands excluded (102 tpd in 1991 & 119 tpd in 1992 from Figure 3)

Figure 5 Distribution of Municipal Solid Waste Arisings by Region

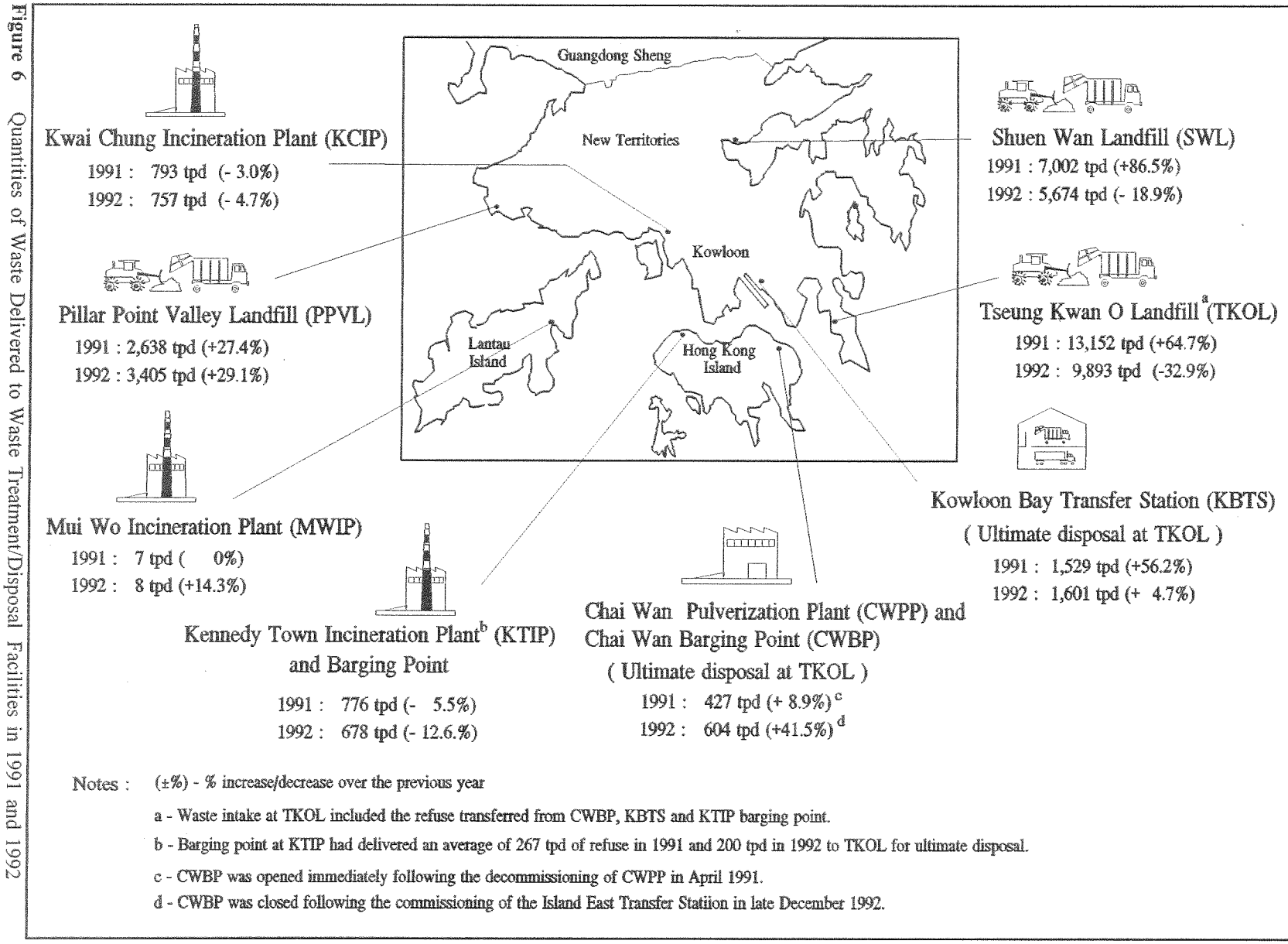


Figure 6 Quantities of Waste Delivered to Waste Treatment/Disposal Facilities in 1991 and 1992

Notes : (±%) - % increase/decrease over the previous year

a - Waste intake at TKOL included the refuse transferred from CWBP, KBTS and KTIP barging point.

b - Barging point at KTIP had delivered an average of 267 tpd of refuse in 1991 and 200 tpd in 1992 to TKOL for ultimate disposal.

c - CWBP was opened immediately following the decommissioning of CWPP in April 1991.

d - CWBP was closed following the commissioning of the Island East Transfer Statiion in late December 1992.

3. WASTE CHARACTERISTICS

Composition of Domestic and Commercial & Industrial Wastes

3.1 The composition of domestic and commercial & industrial wastes in Hong Kong from 1989 to 1992 is shown in Figure 7. The major constituents are paper, putrescibles, plastics and rags. In general, together they account for over two thirds of the domestic waste or the commercial & industrial waste quantity by weight. The proportions of most major waste components have remained fairly constant over the past few years. One exception is putrescibles which have decreased by 7% in domestic waste and increased by 5% in commercial & industrial waste in 1991, whilst their contents in the respective wastes increased by 3% and decreased by 7% in 1992. The rags content of commercial & industrial waste decreased by 12% in 1991 and increased by 3% in 1992. The plastic content in the commercial & industrial waste indicated an increase of 4% in 1992.

3.2 The compositions of waste collected in both the Urban Area and the New Territories (N.T.) for 1991 and 1992 are compared in Figure 8 & Figure 9 respectively. The composition of domestic waste in the two regions was very similar for both 1991 and 1992. This observation is consistent with the findings of the previous years except for a drop in putrescibles in the Urban Area for 1991 whilst its content increased in the N.T. for 1992. However, for commercial & industrial waste, a comparison reveals some inconsistent fluctuations. In 1991 and 1992, the domestic waste collected in the urban area contained significantly less putrescibles and rag, but more paper and plastic than those collected in the N.T.. The plastic content in the domestic waste collected in both regions became less significant in 1992, whilst the relative abundance of the putrescibles from the N.T. indicated an increase. Whilst the paper content in the domestic waste remained steady in 1992, its content in the commercial & industrial waste increased in both regions. For other minor constituents, glass and ferrous metal in the domestic waste indicated a small increase in 1992, whilst the wood content in commercial & industrial waste from the N.T. decreased slightly in 1992. The observation in unclassified constituents has indicated an inconsistent fluctuation in both 1991 and 1992, especially for the medium size unclassified constituent which has showed a noticeable increase in both regions. The smallest size unclassified constituent in commercial & industrial waste became less significant in the Urban Area in 1992.

Comparison with Other Cities and Countries

3.3 Figure 10 compares the composition of municipal solid waste disposed of in a number of cities and countries. The characteristics of municipal solid waste vary considerably between cities depending on social habits, public environmental awareness, socio-economic and climatic factors that affect the waste generation pattern and the extent of waste recovery before disposal. The comparison suggests that Hong Kong's municipal solid waste may be characterised as being relatively low in the content of paper, putrescibles, metal and glass but relatively high in that of plastics, and other minor and miscellaneous constituents. The same characteristic had been observed in previous years. The relatively low paper content is probably a reflection of the degree of recycling activity that takes place in Hong Kong. The relatively high proportion of plastics and low proportion of glass probably reflect the extensive use of plastic bags and packaging, and the unpopular use of glass bottles in Hong Kong.

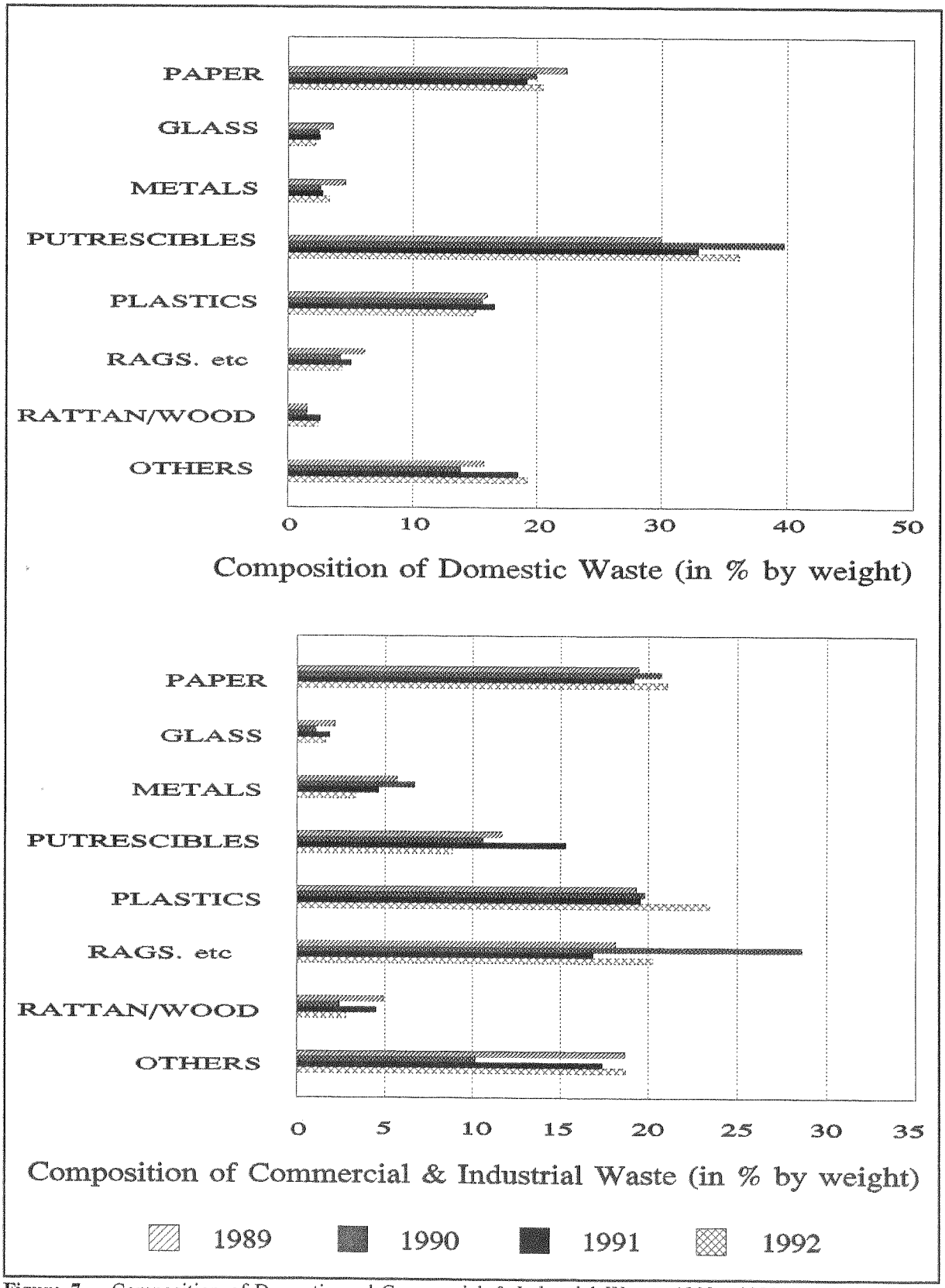
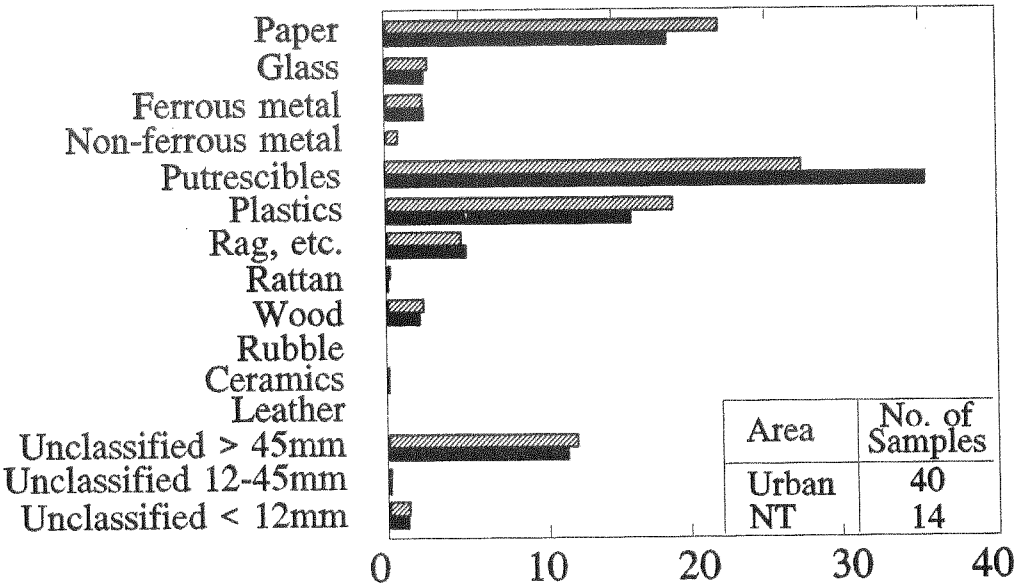
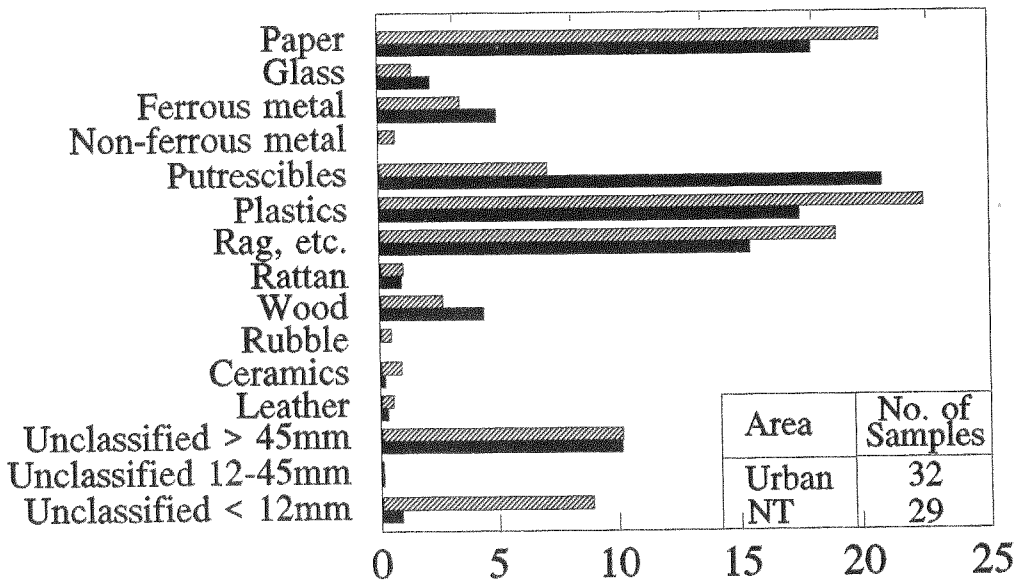


Figure 7 Composition of Domestic and Commercial & Industrial Wastes 1989 - 1992



Composition of Domestic Waste (in % by weight)

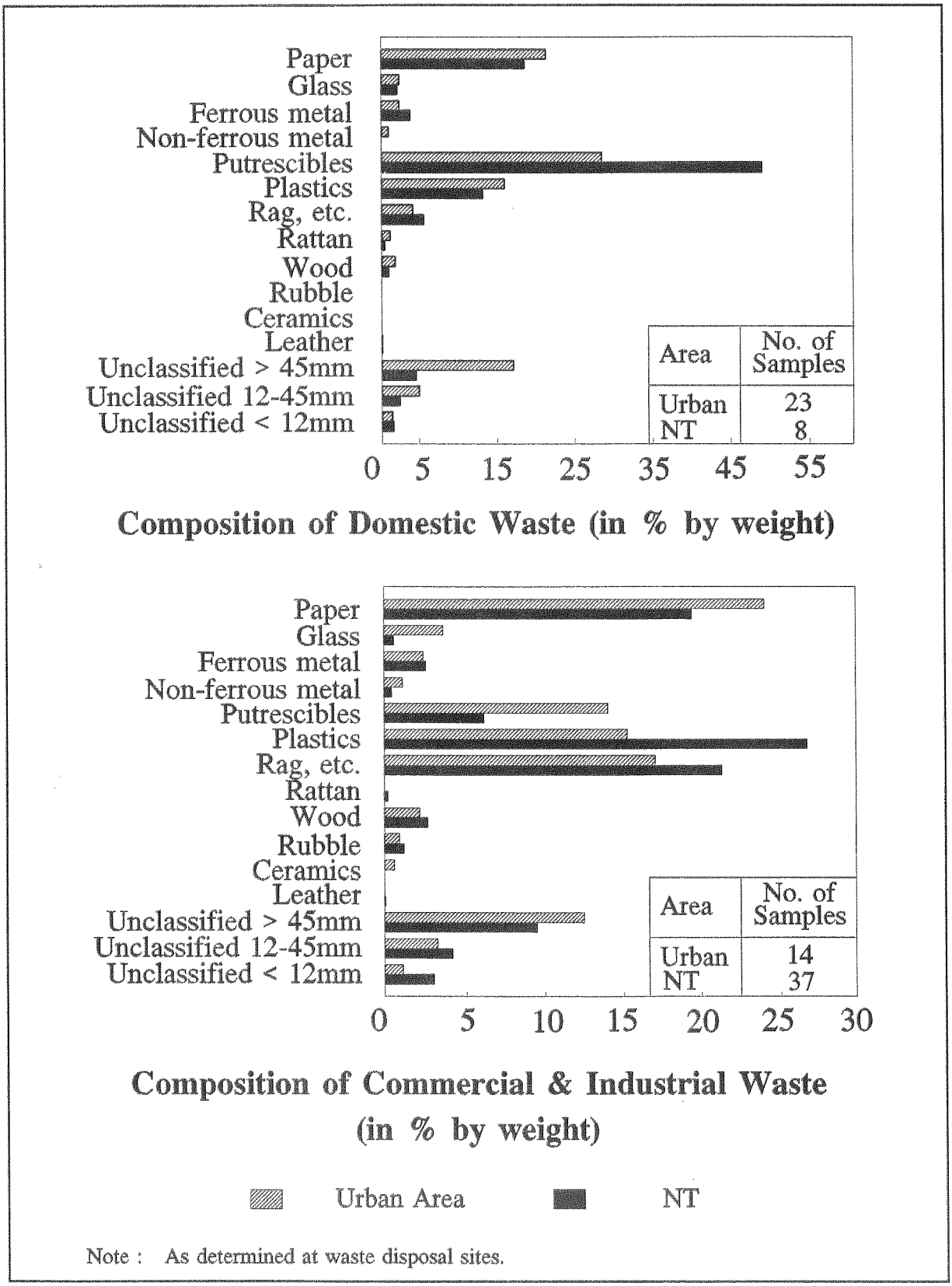


Composition of Commercial & Industrial Waste (in % by weight)

Urban Area NT

Note: As determined at waste disposal sites.

Figure 8 Comparison between Waste Composition in the Urban Area and the New Territories in 1991



Note : As determined at waste disposal sites.

Figure 9 Comparison between Waste Composition in the Urban Area and the New Territories in 1992

		Percentage (by Fresh Weight) of Components									
Location	Year	Paper	Putrescibles and Yard Waste	Textiles	Leather, Rubber & Wood	Plastics	Metals	Glass	Fine Material	Misc.	Source of Info.
Hong Kong	1992	20.6	29.0	8.0	4.2	16.8	3.2	2.2	-	16.1	-
Macau	1991	21.8	35.9	14.6	-	11.2	2.2	3.3	-	11.0	n
Singapore	1990	28.3	44.4	3.0	-	11.8	4.8	4.1	-	3.6	b
Taipei	1989	22.6	31.5	7.5	1.3	14.3	6.2	8.4	-	8.2	a
Kaoshung	1989	19.3	28.8	4.2	2.0	18.6	6.3	4.6	-	6.2	a
Sydney	1987	20.9	48.0	2.3	2.1	7.6	6.3	9.3	-	3.5	c
Greater Melbourne	1985	20.9	42.9	1.6	0.3	9.9	5.9	16.1	-	2.4	d
Paris	1985	39.5	18.6	-	-	7.6	4.6	8.9	14.1	6.7	e
Tokyo	1985	38.4	35.6	4.0	1.0	11.9	5.7	-	-	3.4	f
United Kingdom	1990	33.0	20.0	4.0	-	8.0	8.0	10.0	-	17.0	g
Taiwan	1989	14.0	34.8	8.6	4.5	12.9	6.0	4.9	-	14.3	a
Switzerland	1989	30.6	29.4	3.1	4.3	13.4	5.9	8.7	-	4.6	h
United States	1988	34.2	28.4	2.4	7.0	9.2	8.1	7.1	-	3.6	i
France	1988	30.0	25.0	4.0	-	6.0	5.0	12.0	18.0	-	j
New Zealand	1988	30.5	24.0	4.9	-	8.3	7.8	11.2	-	13.3	k
Germany (FRG)	1985	16.0	29.9	2.0	-	5.4	3.2	9.2	10.1	24.2	m

Figure 10 Composition of Municipal Solid Waste in a number of Cities and Countries

Source of Information :

a : "WEIC 0013 - Waste Information Exchange" (in Chinese), Mar 1990, pp 32-34, Information Centre of Waste Exchange, Taiwan.

b : Quoted from Engineering Services Department, Singapore.

c : "Metropolitan Waste Disposal Authority, Annual Report 1988-1989", pp 63, Metropolitan Waste Disposal Authority, Australia (NSW)

d : "Publication no. 239 - Municipal Waste Services in Victoria", Dec 1985, pp5-6, 25, Environment Protection Authority, Australia (NSW)

e : Quoted from Agence Nationale pour la Recuperation et l'Elimination des Dechets, France

f : "Recycling of Household Waste in Japan", pp6-9, Clean Japan Centre, Japan

g : "Recycling-Can Local Authority Make It Pay", Paper to National Society for Clean Air and Environmental Protection, Apr 1991. John Barton, Warren Spring Laboratory, United Kingdom.

h : "Waste Management in Switzerland", pp 5, Department of Environment, Switzerland.

i : "Characterization of Municipal Solid Waste in United States : 1990 Update - Executive Summary", June 1990, pp ES-11, USEPA

j : "Les Chiffres cles des Dechets" (in French), Jan 1989, pp 4-5, Agence Nationale pour la Recuperation et l'Elimination des Dechets, France

k : "The Interdata Environmental Resource Management Handbook" to be published in 1992, Institute of Waste Management, New Zealand.

m : "Environmental Figures 1988/89" (in German), pp 422, Federal German Environmental Protection Agency, FRG.

n : "Central de Incineracao dos Residuos solidos ds Macau", 1992, Macau

Moisture Content and Waste Density

3.4 The moisture content of domestic and commercial & industrial wastes in Hong Kong for 1991, 1992 as shown in Figure 11 is similar to that observed in 1989 and 1990. The average moisture content for domestic waste was 40% in 1991 and 54% in 1992, as compared to 34% in 1989 and 43% in 1990. The corresponding figures for commercial & industrial wastes was 27% in both 1991 and 1992, as compared to 23% in both 1989 and 1990. In terms of frequency distribution, the distribution for domestic waste was fairly symmetrical and smooth which probably reflects the more consistent nature of the waste samples. The distribution for the commercial & industrial wastes showed obvious irregularity and skewness which is probably the result of the relatively specific nature of individual batches/samples of the wastes from areas of particular or different commercial/industrial activities.

3.5 The average bulk densities of the major waste types in 1991 and 1992 are shown in Figure 12. The waste densities in 1991 are generally higher than those in 1990 except for a significant drop in the density of commercial waste for which the number of samples obtained may be too small to be statistically representative. In 1992, the density of domestic waste reduced by 16% whilst it increased by 35% and 12% for commercial and industrial wastes respectively. The fluctuation in densities of commercial waste may be viewed as another result of sample size which is too small to be statistically representative. Since there was not much change in the waste composition, the significant reduction in density could be the result of changes in the sampling or measuring procedures. It was also noted that the average bulk density for domestic waste is considerably higher than those for the other waste types. This is attributed to the widely use of Refuse Collection Vehicles with compression ability for collection, and the typical higher moisture content of the domestic waste.

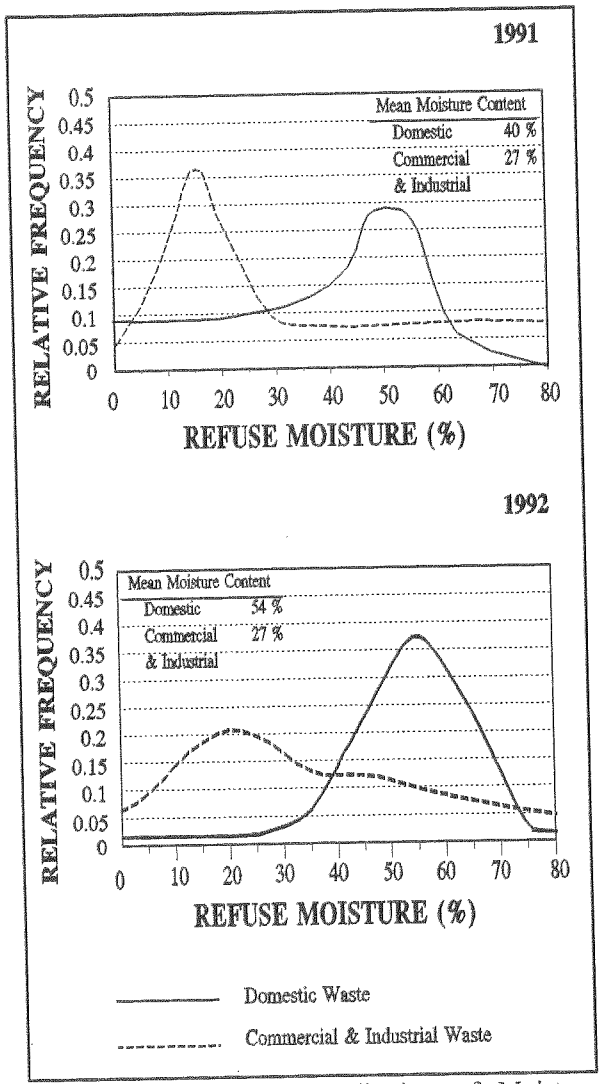


Figure 11 Frequency Distribution of Moisture Content of Domestic and Commercial & Industrial Wastes

Description of Waste	1990		1991		1992	
	Density (kg/m^3)	No. of Samples Collected	Density (kg/m^3)	No. of Samples Collected	Density (kg/m^3)	No. of Samples Collected
Domestic	184	131	271	119	228	62
Commercial	110	3	93	4	125	14
Industrial	107	89	120	92	135	92

Figure 12 Bulk Density of Domestic, Commercial and Industrial Wastes in 1990, 1991 and 1992

Composition of Construction Waste

3.6 Construction waste generated by different construction or demolition activities have distinct characteristics. It is thus a common practice to categorize construction waste according to its source of arisings. Based on field observation at landfills, the composition of construction waste received at landfills in 1991 and 1992 are shown in Figure 13. The constituent distribution of construction waste by category and by weight for 1992 is shown in Figure 14. The results of the field observation indicate that about one fourth of the construction waste received at landfill would be suitable without further processing for disposal at public dumping sites. Most of these were excavated materials from site formation and foundation works and rubble type materials from building demolition and roadwork. Some of these materials are currently being used on landfill sites for site preparation works and maintenance of access roads. Suitable soil/sand materials are sometimes used for daily covers on landfill sites.

Reusable/Recyclable Waste Type	% by weight	
	1991	1992
Asphalt	1.7	0.2
Brick/Tiles	5.1	9.3
Concrete/Mortar	15.6	17.1
Reinforced Concrete	3.8	1.7
Rock/Rubble	7.7	5.5
Sand/Soil	48.0	27.6
Sub-total	**81.9**	**61.4**
Non-Reusable/Recyclable Waste Type	% by weight	
	1991	1992
Bamboo	1.1	0.4
Ferrous Metal/ Non-ferrous Metal	1.8	3.5
Glass	0.4	0.3
Junk/Fixtures	0.3	0.4
Plastic	3.1	0.6
Slurry & Mud	---	18.4
Trees	0.5	0.2
Wood	6.0	9.4
Other Organic & Garbage	4.9	5.4
Sub-total	**18.1**	**38.6**
Total	**100.0**	**100.0**

Figure 13 Composition of Construction Waste received at landfills in 1991 and 1992

CONSTITUENT	WASTE CATEGORY				
	Roadwork Material	Excavated Material	Demolition Waste	Site Clearance Waste	Renovation Waste
Asphalt	2.3	0.2	0.0	0.2	0.0
Concrete/Mortar	38.6	5.0	26.2	20.0	21.5
Reinforced Concrete	3.9	0.6	9.3	1.1	0.4
Rock/Rubble	15.8	5.7	9.9	4.8	1.7
Bricks/Tiles	5.0	1.7	22.0	8.5	20.8
Soil/Sand	28.5	20.5	24.0	36.4	13.7
Ferrous Metal	0.7	0.4	2.1	4.3	5.4
Non-ferrous Metal	0.0	0.0	0.4	0.5	1.7
Slurry & Mud	0.0	64.2	0.0	0.0	0.0
Wood	3.0	0.9	3.8	13.1	21.0
Bamboo	0.0	0.0	0.1	0.8	0.4
Trees	0.3	0.2	0.0	0.3	0.1
Glass	0.0	0.0	0.1	0.3	1.4
Plastic	0.1	0.1	0.3	1.0	1.0
Other Organic & Garbage	1.8	0.5	1.8	8.3	9.3
Junk/ Fixtures	0.0	0.0	0.0	0.4	1.6
TOTAL	100.0	100.0	100.0	100.0	100.0

Figure 14 Constituent Distribution of Construction Waste by category and by weight for 1992

Recyclable Content of Waste

3.7 In the 1991 and 1992 summer surveys, special attention was paid to the quality and quantity of recyclables disposed of at landfills. The information collected is useful for the investigation of further opportunities to increase the level of recycling. The major types of recyclable identified and their respective proportions in domestic and commercial & industrial wastes for 1991 and 1992 are shown in Figure 15. The major recyclable materials in the waste streams were still paper and plastic, which together constituted more than 20% by weight of domestic or commercial & industrial wastes received at landfills.

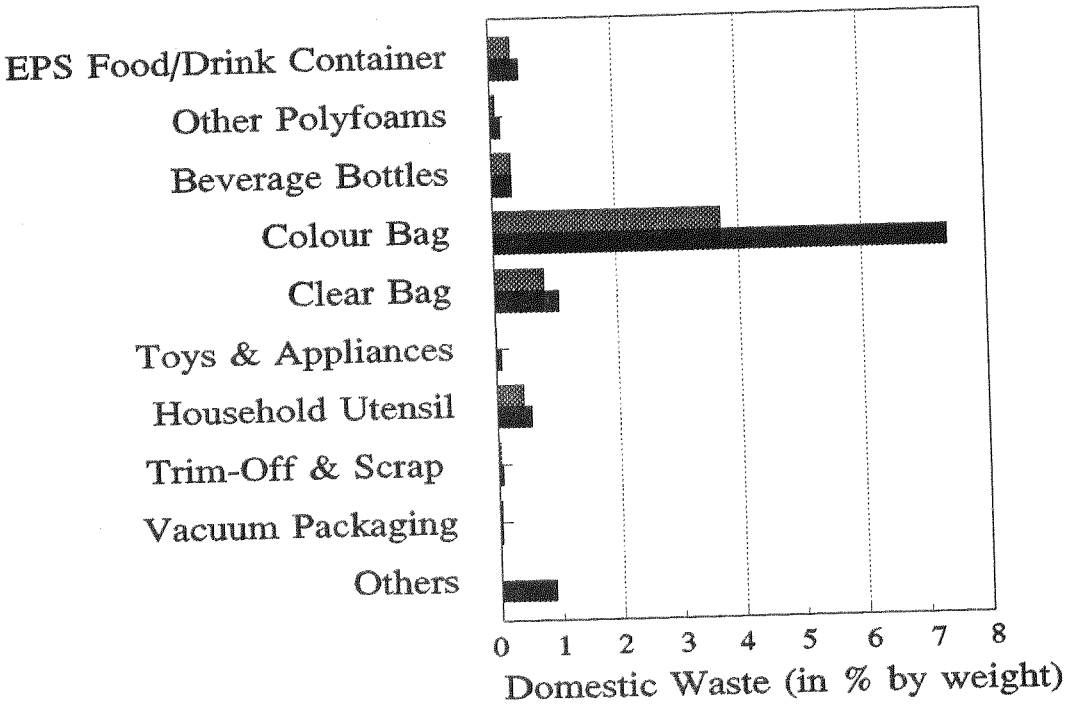
Recyclable Content	1991				1992			
	Domestic		Industrial & Commercial		Domestic		Industrial & Commercial	
	% by weight	Grade	% by weight	Grade	% by weight	Grade	% by weight	Grade
Paper - Writing Paper	0.2	Fair	0.5	Fair	0.3	Bad	1.7	Fair
Paper - Newsprint	6.1	Bad	2.9	Fair	5.3	Bad	3.0	Bad
Paper - Others	5.2	Bad	7.7	Fair	4.5	Bad	9.7	Bad
Glass - Colour Bottle	1.1	Bad	0.4	Fair	1.2	Bad	0.7	Bad
Glass - Clear Bottle	1.0	Bad	0.5	Bad	0.9	Bad	0.6	Bad
Plastic	8.7	Fair-Bad	6.7	Good-Fair	11.0	Fair-Bad	11.6	Fair-Bad
Ferrous Metal	0.8	Bad	1.9	Fair	1.5	Bad	1.9	Bad
Non-ferrous Metal	0.2	Bad	0.1	Fair	0.2	Bad	0.3	Fair
Non-recyclable	76.7	----	79.3	----	75.1	----	70.5	----
Total:	100.0		100.0		100.0		100.0	

Figure 15 Percentage and Grading of Recyclable Content in Domestic and Commercial & Industrial Wastes

Legend on Grade of recyclable :

GOOD : Relatively dry and free from contaminants.
FAIR : Moist and slightly contaminated.
BAD : Damp and heavily contaminated.

3.8 A detailed breakdown of the plastic recyclable by product type is given in Figure 16. Amongst the various items, plastic content comprised 11% by weight of total municipal solid waste excluding construction waste and this amounted to 827 tonnes per day in 1992. Plastic bags comprising mostly shopping bags from supermarkets, stores and food shops/markets, accounted for the largest proportion in plastic content and still remained at high level in 1991 and 1992. There is an increasing trend in the consumption of plastic bags. In commercial & industrial wastes, the quantity of trim-off plastic and scrap plastic was also significant in 1992. The common use of clear plastic bags in the industrial sector was reflected by its significant proportion in the commercial & industrial waste. Food/drink containers made of expanded polystyrene (EPS) were observed in considerable numbers although their proportion by weight was relatively low because of the low density of this material. In 1992, an increase in other minor plastic contents was also noted.



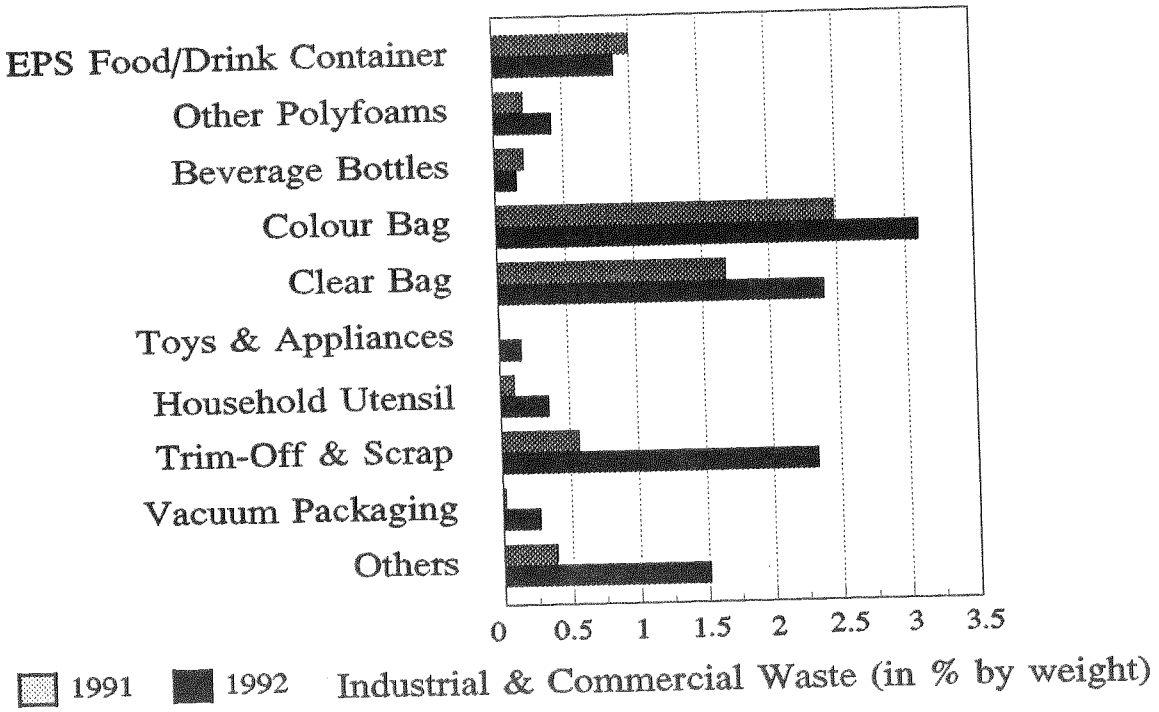


Figure 16 Percentage Composition of Recyclable Plastic Content in Domestic and Commercial & Industrial Wastes

4. WASTE ARISINGS FORECASTS

Waste Generation Rates per Head

4.1 In this report, historical trends of waste arisings were established and forecasts were made by linear projections of these trends on the basis of domestic waste, commercial & industrial waste and construction waste. In order to establish a common base for comparison, waste arisings were converted to per capita/employee generation rate. It is considered that these conversions would work better with the wastes categorised into domestic and commercial & industrial rather than publicly and privately collected.

4.2 Domestic waste arisings are dependent on the size of the territorial population and is therefore converted to per capita generation rate for comparison purpose.

4.3 Commercial & industrial waste arisings are dependent on the working population in relevant commercial and industrial sectors. Commercial & industrial waste arisings were therefore converted into generation rate per employee. The number of employees used covers persons engaged in economic activities grouped under Division 3, 6 and 8 of the International Standard Industrial Classification, i.e. including manufacturing, wholesale, retail, import and export trades, restaurants, hotels, finance, insurance, real estate and business services.

4.4 Apart from trend analysis, the waste generation rates per head also provide a common basis for comparison between the waste generation patterns in different geographical areas. For such comparison, the generation rates for each WAD have been calculated and are given in Figure 17. From this figure, the following major points of interest are noted -

- The arisings per capita for domestic waste in Central, Wanchai and Tsim Sha Tsui business districts remained at 2 to 3 times as much as those in the other residential areas, however the corresponding arisings per employee for commercial & industrial waste are less than those for the other districts in the urban area. The most likely explanation is that a considerable amount of commercial/trade wastes in these business districts was intermixed with the domestic waste handled by the USD's collection system.

- The lower arisings per capita of domestic waste and higher arisings per employee of commercial & industrial waste in the New Territories are probably due to the larger concentration of industrial and manufacturing activities in the region and the result of a strict separation in the collection of domestic and commercial & industrial wastes. The significantly high arisings per employee for Yuen Long and Sai Kung are likely due to the small number of employees in the working population within the regions.

Code Name	District	Domestic Waste (kg/capita/day)		Commercial & Industrial Waste (kg/employee/day)	
		1991	1992	1991	1992
1010	Central & Western	1.48	1.59	0.27	0.37
1020	Wanchai	1.68	1.81	0.27	0.42
1030	Eastern	0.96	1.03	0.93	1.32
1040	Southern	0.91	0.96	1.59	1.23
1000	Hong Kong Island	1.17	1.25	0.51	0.66
2010	Tsim Sha Tsui	2.44	2.91	0.71	0.62
2020	Mong Kok	1.25	1.26	0.27	0.46
2030	Sham Shui Po	0.98	0.89	0.85	0.93
2040	Kowloon City	0.93	1.03	0.98	1.42
2050	Wong Tai Sin	0.69	0.75	0.96	1.27
2060	Kwun Tong	1.04	0.80	1.56	1.92
2000	Kowloon	1.05	1.03	0.95	1.15
1000/2000	Urban Area	1.10	1.11	0.78	0.96
3010	Kwai Chung	0.81	0.71	1.28	1.19
3020	Tsuen Wan	0.77	1.02	2.74	2.83
3030	Tuen Mun	0.70	0.86	2.51	2.43
3040	Yuen Long	0.90	0.91	3.20	4.27
3050	North	0.86	0.93	1.70	1.18
3060	Tai Po	0.87	0.80	1.71	3.14
3070	Sha Tin	0.80	0.86	1.49	1.88
3080	Sai Kung	0.81	0.68	2.99	6.12
3000	New Territories	0.80	0.84	1.99	2.24
4000	Outlying Islands	1.90	2.49	0.00	0.00
	Territorial Average	0.98	1.01	1.09	1.29

Figure 17 Geographical Variations in Waste Generation Rates

Correlation between Waste Arisings and Gross Domestic Product (GDP)

4.5 It has been established in previous reports that municipal solid waste generation has a close relationship with the Territory's economic activities as measured by the GDP. With a re-definition of "construction waste" as explained in paragraph 4.11, data on its quantities can only be traced back to 1986. The limited data available is insufficient for making any statistically representative analysis. For this reason, the correlation between waste arisings and the GDP of the respective years is better limited only to domestic and commercial & industrial wastes as shown in Figure 18. Assuming that this correlation continues to exist, the future arisings of domestic, commercial and industrial wastes can be determined based on the GDP figures for future years as predicted by the Economic Services Branch. Prediction of the arisings of municipal solid waste will be further discussed in later sections.

Limits to the Growth of Domestic Waste Generation Rate

4.6 In previous reports, historical trends of domestic waste generation in several developed cities and countries were analyzed. The results reveal that there is generally a limit to the growth of per capita arisings for domestic waste. Based on trends observed in Japan, Singapore and the United States, it was previously considered that the limit of growth for publicly collected waste in Hong Kong should be taken as 1.0 kg/person/day.

4.7 Figure 19 shows the historical trend of domestic waste generation in Hong Kong for the period from 1984 to 1992. It was found that the waste generation rate has been growing steadily without showing any tendency to flatten off. In view of the many factors involved, it is difficult to forecast the limit of growth to the domestic waste generation rate in Hong Kong. For this reason, no attempt has been made to impose such a limit in predicting the domestic waste arisings within the forecasting horizon of this report.

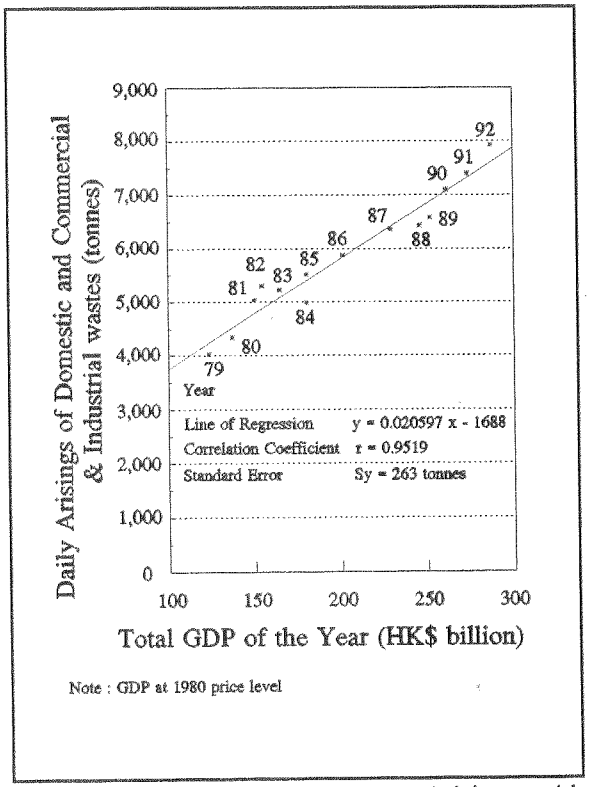


Figure 18 Correlation of Waste Arisings with Total Gross Domestic Product over the period 1979-1992

Forecast of Domestic Waste Arisings

4.8 The historical trend established in Figure 19 shows that the per capita generation rate for domestic waste increased at an average rate of 3.6% per annum. By linear projection of this trend, the generation rate of domestic waste will reach 1.33 kg per capita per day in 2001. The quantity of domestic waste for future years is then calculated by multiplying the projected per capita waste generation rate by the future population in the respective year predicted by the Working Group on Population Distribution.

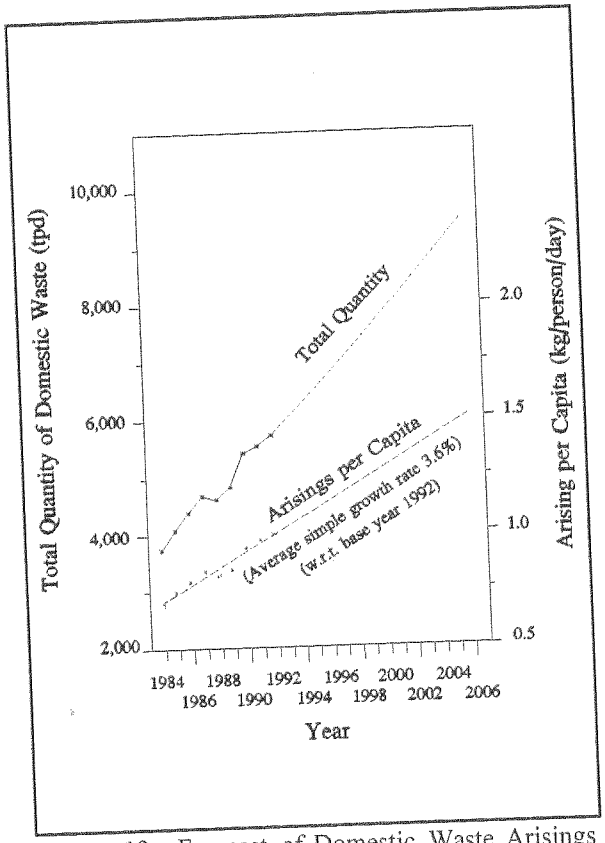


Figure 19 Forecast of Domestic Waste Arisings

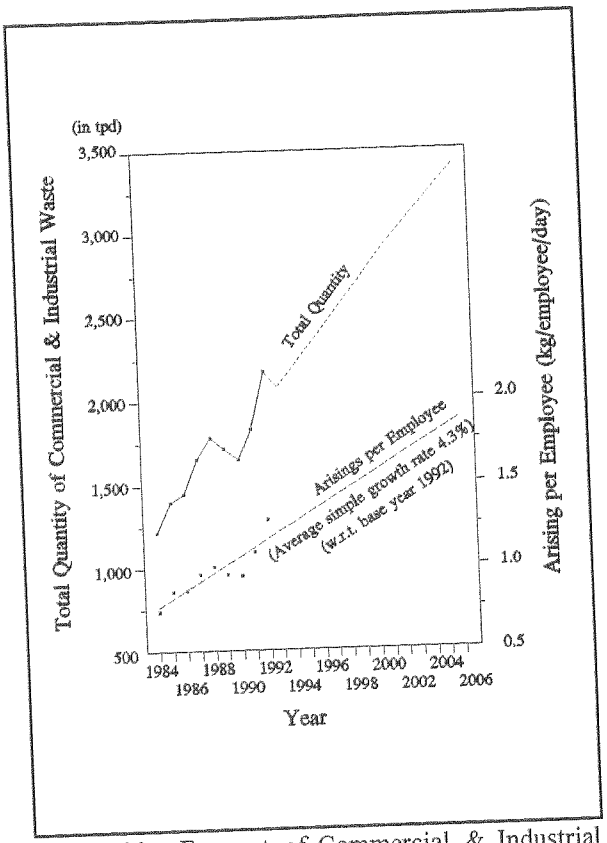


Figure 20 Forecast of Commercial & Industrial Waste Arisings

Forecast of Commercial & Industrial Waste Arisings

4.9 For forecasting the commercial & industrial waste arisings, a similar trend for the arisings per employee per day over the period has been established in Figure 20. It shows that there is an average growth rate of 4.3% per annum. The future per employee generation rate is derived from a linear projection of this historical trend, which gives 1.63 kg per employee per day in 2001. The total quantity of commercial & industrial wastes for future years is determined by multiplying the projected arisings per employee by the number of employees in the respective year predicted by Working Group on Population Distribution.

Forecast of Construction Waste Arisings

4.10 In previous reports, the forecast of construction waste arisings was obtained by a simple linear extrapolation of the historical trend of total quantity. This method of projection worked very well for the years up to 1985. Since then, there have been a dramatic increase in the quantity of construction waste received at landfills (see Figure 21) and the actual growth has deviated considerably from the line of regression.

4.11 It has become clear that the quantity of construction waste received at landfills is closely related to the availability and capacity of public dumps and the quantity of excavated waste approved for dumping at marine spoil grounds. With this perspective, the previous approach of considering the quantity received at landfills alone

is not appropriate especially when there is significant fluctuation in public dumping capacity. In this report, the trend of construction waste arisings is analyzed in combination with the quantities of public dumping waste and excavated waste dumped at spoil grounds. For simplicity in presentation, all these materials are collectively referred to as "construction waste" in the subsequent portion of this report. However, it should be noted that complete records for all these materials could only be traced back to 1986. The reliability of the trend established will be severely restrained due to the lack of an extensive historical database.

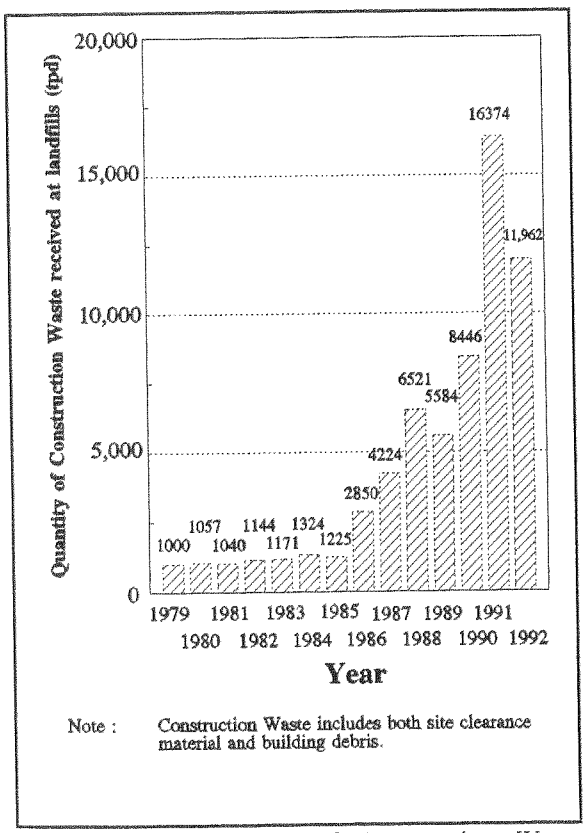


Figure 21 Quantities of Construction Waste Received at Landfills from 1979 - 1992

4.12 Figure 22 sets out the quantities of construction waste delivered to various disposal facilities from 1986 to 1992. The increase of 94% in the quantity of construction waste received at landfills in 1991 represents the greatest increase in a single year and has brought about the shortfall of landfill capacity at Shuen Wan Landfill and Tseung Kwan O Landfill. The increase coincided with the substantial reduction in disposal at public dumps in 1991. Such reduction may be attributed to the following reasons -

- In 1991, there was generally a shortfall of public dumping sites throughout the territory, particularly in the urban areas. Landfills became more convenient disposal points for construction waste.

- More stringent quality control at public dumps. Construction waste that contained excessive floatable or other unsuitable materials and that mixed with materials of particle size exceeding 250mm was rejected for public dumping in 1991. In order to comply with the public dumping licence conditions, sorting/separation of construction waste was required leading to extra resource implications. This made the option of landfill disposal more economically attractive.

- Due to the acute labour shortage and increasing labour cost in the construction industry, it became less economically attractive to recover reusable materials from the construction waste for either local beneficial reuse or reuse on other construction sites.

- Improved enforcement of dumping at sea controls since 1990 may have resulted in less construction waste being illegally dumped at sea than in previous years.

Year	Quantity of Construction Waste (tpd)				No. of Workers Engaged on Construction Sites	Waste per Site Worker (WGF) (ton/employee)
	Landfills	Public Dumps	Marine Dumps	Total		
1986	2,850	15,781	486	19,117	67,443	0.2834
1987	4,224	13,068	1,125	18,417	71,615	0.2572
1988	6,521	13,315	98	19,934	73,456	0.2714
1989	5,584	12,822	879	19,285	70,504	0.2735
1990	8,446	8,901	4,780	22,127	71,114	0.3112
1991	16,374	4,882	4,835	26,091	63,418	0.4114
1992	11,962	13,167	3,875	29,004	63,148	0.4593

Figure 22 Disposal Means and Arising per Site Worker of Construction Waste

4.13 In 1992, there was a reduction in quantity of construction waste disposed of at landfills and a corresponding increase in disposal at public dumps which may be attributed to the following reasons -

- In 1992, the Hung Hom Bay Public Dump which was a very convenient disposal site in the urban area was opened.
- The implementation of relaxation of public dumping licence conditions since October 1992 has allowed construction waste containing components of any particle size and small content of timber to be disposed of at public dump sites.

4.14 The quantity of construction waste is largely related to the level and type of construction activities. A reasonable indication of construction activity is the number of workers employed in construction sites. Analysis of the historical data of Waste Generation Factor (WGF) for 1986-1992 in Figure 22 shows that the WGF did not change significantly from 1986 to 1989, but it began to increase from 1990 to a peak value in 1992. A correlation was derived from these historical data using a linear regression. It was further assumed that the WGF in 1992 would remain unchanged within the planning horizon of this report. Forecasts on the future employment sizes in the construction industry (ISIC Division 5) are available from Planning Department. However, the future number of workers employed on construction sites are estimated from the average proportion of site staff in the total work force for the period from 1986 to 1992. Multiplying the forecasted numbers of on-site workers by the waste generation factor per worker obtained above, the future arisings of construction waste are predicted and shown in Figure 23.

Erratum

Figure 22, page 26

The following figures for 1992 should be revised as
"No. of Workers Engaged on Construction Sites" = 62,23
"Waste per Site Worker (WGF) in ton/employee" = 0.46

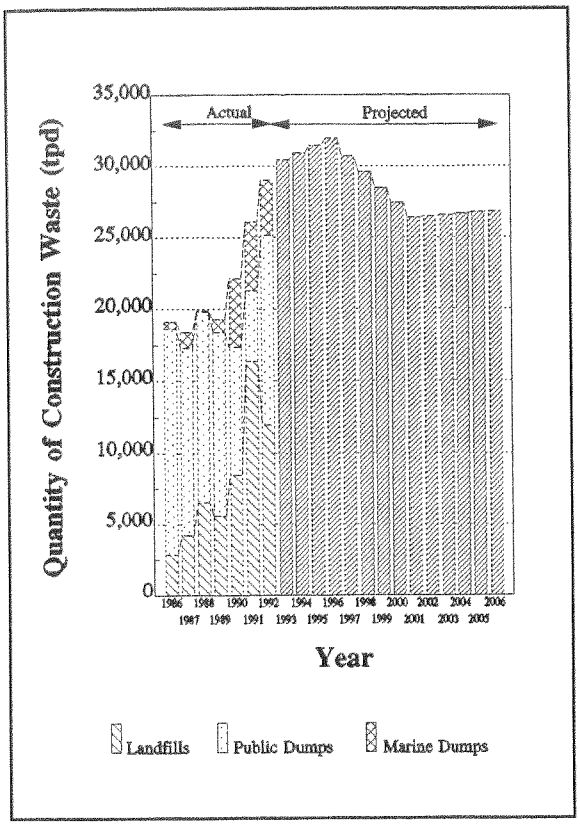


Figure 23 Forecast of Construction Waste Arisings

4.15 The proportion of construction waste that will be received at landfills depends very much on the quantities disposed of at other facilities, i.e. public dumps, spoil grounds or possible recycling plants. The waste disposal pattern is affected by many factors such as the available capacities of the various disposal facilities, quality of materials acceptable at such facilities, and related fiscal or administrative control measures adopted by Government. With the expected implementation of charging for disposal at landfills in 1994, it is envisaged that more construction waste will be disposed of at public dumps and less construction waste at landfills from 1994 onwards.

Forecast of Total Arisings of Domestic and Commercial & Industrial Wastes

4.16 According to the waste disposal strategy, the disposal of domestic, commercial and industrial wastes will be at landfills. Knowing the total arisings of these wastes is essential for planning the provision of landfill capacity. One way of forecasting their total quantities is to combine the forecasts for individual waste categories. The result thus obtained is shown in Figure 24. It has been mentioned earlier that the total quantity of these wastes can also be forecasted based on its correlation with the GDP figures. This provides a simpler method of projection and the result obtained is also shown in Figure 24 for comparison purpose. It can be noted that the two different methods of projection give results which agree very well.

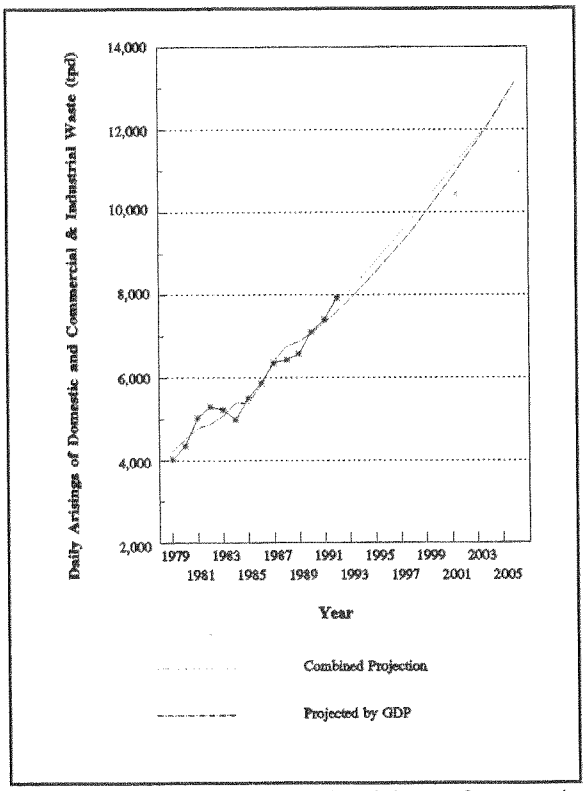


Figure 24 Forecast of Total Arisings of Domestic and Commercial & Industrial Wastes

Forecast of Waste Arisings in Each Waste Arisings District

4.17 For both the siting of waste handling and disposal facilities and the planning of waste collection and transportation managements, it is necessary to know the future geographical distribution of waste arisings. Forecasts of the waste quantities produced in each Waste Arisings District (WAD) are therefore made using the respective waste generation rates of each WAD and the population distribution predicted by the Working Group on Population Distribution. The detailed procedure is as follows -

(a) Select the planning years for which the waste arisings in each WAD are required. (In this report, the years selected are 1993, 1996, 2001 and 2006.)

(b) For each year selected, obtain the forecasted territorial arisings (control total) of each waste category based on the projection in the previous sections.

(c) For each waste category, assume an initial single growth rate for the different waste generation factors (per capita/employee) of all WADs. This gives the future waste generation factors at district level, which after multiplying by the respective predicted population (or employee population), will give the forecasted waste quantities in each WAD.

(d) Sum up the waste arisings of all WADs and compare it with the control total obtained in (b).

(e) Adjust the initial growth rate and repeat steps (c) & (d) above until the sum of the waste arisings from all WADs agrees with the control total obtained in (b).

4.18 As with all other predictions, the forecasts presented in this report are dependent upon the validity of the numerous assumptions made. In particular the forecasts are subject to the following uncertainties -

- Prediction of future demographic trends.
- Changes in social patterns, environmental awareness, population density, levels and characteristics of industrial and commercial activities, manufacturing technology and trends in product packaging.
- Level of recycling activities and exploration of domestic and overseas markets for recovered materials.
- Possible limits to the growth of waste generation rates per capita/employee.
- Progress of the new town developments and the redevelopments in the urban area.
- Developments of the Government's waste minimisation policy.

4.19 Notwithstanding the above limitations, the figures presented are considered to be the best available and serve to indicate clearly the broad trends of future waste arisings for strategic and sub-regional planning purposes. It is necessary to continue the current monitoring exercises, taking account of all the new trends and future developments.

	Waste Quantities in Tonnes per Day																			
	Domestic Waste								Commercial & Industrial Waste				Construction Waste				Total			
	Publicly Collected				Privately Collected															
District	1993	1996	2001	2006	1993	1996	2001	2006	1993	1996	2001	2006	1993	1996	2001	2006	1993	1996	2001	2006
Central & Western	360	411	458	530	65	74	82	95	80	90	110	130	2495	2175	1285	1305	3,000	2,750	1,935	2,060
Wanchai	252	270	303	313	98	105	117	122	50	60	70	85	2320	900	765	780	2,720	1,335	1,255	1,300
Eastern	417	474	535	588	168	191	215	237	140	160	195	225	2330	2420	2650	2690	3,055	3,245	3,595	3,740
Southern	225	243	279	347	25	27	31	38	45	50	60	70	1620	1270	1360	1380	1,915	1,590	1,730	1,835
HK ISLAND	1,254	1,398	1,575	1,778	356	397	445	492	315	360	435	510	8,765	6,765	6,060	6,155	10,690	8,920	8,515	8,935
Yau Ma Tai	293	348	442	532	82	97	123	148	100	115	140	165	1180	1995	860	870	1,655	2,555	1,565	1,715
Mong Kok	159	162	177	191	61	63	68	74	40	45	55	65	285	750	670	680	545	1,020	970	1,010
Sham Shui Po	293	293	310	402	42	42	45	58	115	135	165	190	1620	3415	1945	1975	2,070	3,885	2,465	2,625
Kowloon City	313	325	446	614	87	90	124	171	150	170	210	240	920	2055	3055	3100	1,470	2,640	3,835	4,125
Wong Tai Sin	272	309	374	323	23	26	31	27	85	95	115	135	825	1655	1600	1625	1,205	2,085	2,120	2,110
Kwun Tong	413	440	477	573	37	40	43	52	340	395	480	560	1390	2300	2610	2650	2,180	3,175	3,610	3,835
KOWLOON	1,743	1,877	2,226	2,635	332	358	434	530	830	955	1,165	1,355	6,220	12,170	10,740	10,900	9,125	15,360	14,565	15,420
Kwai Chung	304	333	375	370	21	22	25	25	165	190	230	270	3120	1665	1850	1880	3,610	2,210	2,480	2,545
Tsuen Wan	193	193	207	238	87	87	93	107	260	295	365	425	1020	1880	1165	1185	1,560	2,455	1,830	1,955
Tuen Mun	347	402	457	603	33	38	43	57	110	130	155	185	1855	1840	1360	1380	2,345	2,410	2,015	2,225
Yuen Long	247	318	394	437	13	17	21	23	140	160	195	225	2565	1270	1180	1195	2,965	1,765	1,790	1,880
North	167	223	242	307	13	17	18	23	20	20	25	30	1575	1105	620	630	1,775	1,365	905	990
Tai Po	173	189	205	240	47	51	55	65	90	105	130	150	570	1040	670	680	880	1,385	1,060	1,135
Shatin	402	459	516	629	58	66	74	91	110	130	155	185	2390	2435	1430	1450	2,960	3,090	2,175	2,355
Sai Kung	96	134	251	301	19	26	49	59	45	50	65	75	1690	920	925	940	1,850	1,130	1,290	1,375
NEW TERRITORIES	1,929	2,251	2,647	3,125	291	324	378	450	940	1,080	1,320	1,545	14,785	12,155	9,200	9,340	17,945	15,810	13,545	14,460
OUTLYING ISLANDS	125	145	400	510	0	0	0	0	0	0	0	0	665	855	425	430	790	1,000	825	940
TERRITORIAL TOTAL	5,051	5,671	6,848	8,048	979	1,079	1,257	1,472	2,085	2,395	2,920	3,410	30,435	31,945	26,425	26,825	38,550	41,090	37,450	39,755

Figure 25 Forecast Arisings of Domestic Waste, Commercial & Industrial Waste and Construction Waste in Each Waste Arisings District

OBJECTIVES OF THE WASTE ARISINGS MONITORING PROGRAMME

The objectives of the waste arisings monitoring programme are related to the design needs within the waste management system and are as follows -

- To establish the types of wastes that need to be monitored as separate classes. The need for this may be due to the large quantities involved, e.g. household waste, commercial waste, industrial waste, etc.; or due to the nature of the waste which requires special handling and disposal managements, e.g. chemical wastes, clinical waste, sludge, etc.

- To determine the quantities and characteristics of each waste type and the geographical distribution of waste generation in order to provide the design data for the waste handling facilities and to direct waste to the most convenient and appropriate disposal or treatment facility.

- To forecast the future arising of each waste type and change in geographical distribution of waste arisings in order to allow adequate flexibility to cope with the design of the waste management system.

- To establish correlations between waste arisings and socio-economic parameters, e.g. population, employee population, construction activity and GDP growth, etc., such that more accurate predictions can be made of the total future arisings.

- To establish trends in the constituents of waste types such that more accurate predictions can be made of the future nature of waste types.

- To establish limits to the growth of waste arisings in Hong Kong principally by observing trends occurring in other cities or countries.

- To determine the waste management requirements for future municipal solid waste arisings.

LIST OF ABBREVIATED TITLES OF GOVERNMENT DEPARTMENTS

A&FD	Agriculture and Fisheries Department
EMSD	Electrical and Mechanical Services Department
EPD	Environmental Protection Department
CED	Civil Engineering Department
C&SD	Census and Statistics Department
MD	Marine Department
PlanD	Planning Department
RSD	Regional Services Department
USD	Urban Services Department

SAMPLE SURVEY FORM USED FOR WEIGHBRIDGE MONITORING

ENVIRONMENTAL PROTECTION DEPARTMENT

Sheet ____

Monitoring of Waste Arisings

Record of Incoming Lorries at Disposal Site

Disposal Site : _____ Survey Date : _____ Surveyor : _____

Time	Vehicle No.	Waste Cat.	Waste Content	Arising Area /District/ Collection Route	Owner-ship	Payload	Area Code

BREAKDOWN OF WASTE DELIVERED TO TREATMENT PLANTS, REFUSE TRANSFER STATIONS AND LANDFILLS IN 1991

Disposal Facility	1991 Waste Intake by Category (tpd)						Incineration Ash
	Public	Private	Construction	Sludges	Special	Total	
Kennedy Town Incineration Plant (KTIP)	440	69	-	-	-	509	131
Kennedy Town Incineration Plant Barging Point	267	-	-	-	-	267 *	
Kwai Chung Incineration Plant (KCIP)	793	-	-	-	-	793	199
Mui Wo Incineration Plant (MWIP)	7	-	-	-	-	7	2
Chai Wan Pulverization Plant (CWPP) and Chai Wan Barging Point (CWBP) ⋆	427	-	-	-	-	427 *	
Kowloon Bay Refuse Transfer Station (KBTS)	1,529	-	-	-	-	1,529 #	
Tseung Kwan O Landfill (TKOL)	118	1,804	8,865	90	52	10,929	
Shuen Wan Landfill (SWL)	595	356	5,896	150	5	7,002	
Pillar Point Valley Landfill (PPVL)	462	521	1,614	31	10	2,638	
Total :	4,638	2,750	16,375	271	67	24,101	332 *
	23,763						

* Waste quantity subsequently transferred to Tseung Kwan O Landfill by barge.

\# Waste quantity subsequently transferred to Tseung Kwan O Landfill by container.

⋆ CWBP was opened immediately following the decommissioning of CWPP in April 1991.

BREAKDOWN OF WASTE DELIVERED TO TREATMENT PLANTS, REFUSE TRANSFER STATIONS AND LANDFILLS IN 1992

Disposal	Public	Private	Construction	Sludges	Special	Total	Incineration Ash
Kennedy Town Incineration Plant (KTIP)	405	70	-	-	3	478	136
Kennedy Town Incineration Plant Barging Point	200	-	-	-	-	200 *	
Kwai Chung Incineration Plant (KCIP)	755	-	-	-	2	757	177
Mui Wo Incineration Plant (MWIP)	8	-	-	-	-	8	2
Chai Wan Barging Point (CWBP) ⋆	604	-	-	-	-	604 *	
Kowloon Bay Refuse Transfer Station (KBTS)	1601	-	-	-	-	1,601 #	
Tseung Kwan O Landfill (TKOL)	115	2,030	5,174	79	90	7,488	
Shuen Wan Landfill (SWL)	612	553	4,424	56	29	5,674	
Pillar Point Valley Landfill (PPVL)	522	459	2,364	21	39	3,405	
Total :	4,822	3,112	11,962	156	163	20,215	315 *
	19,896						

* Waste quantity subsequently transferred to Tseung Kwan O Landfill by barge.

\# Waste quantity subsequently transferred to Tseung Kwan O Landfill by container.

⋆ CWBP was closed following the commissioning of the Island East Refuse Transfer Station in late December 1992.

EXPORT OF RECOVERED WASTE MATERIALS FOR 1990 TO 1992

Categories of Waste Materials	1990		1991		1992	
	Quantity (tonnes)	Value ($,000)	Quantity (tonnes)	Value ($,000)	Quantity (tonnes)	Value ($,000)
A) Wood & Paper						
- Wood (incl. sawdust)	15,447	9,672	21,096	10,988	18,085	9,551
- Paper	542,268	390,729	580,399	441,780	496,902	371,840
Sub-total :	557,715	400,401	601,495	452,768	514,987	381,391
B) Glass						
Sub-total :	2,241	1,982	1,055	991	853	997
C) Plastics						
- Polyethylene	25,214	55,872	34,946	97,788	50,870	137,709
- Polystyrene & Copolymers	29,398	88,427	45,761	139,855	67,447	168,324
- Polyvinyl Chloride	31,207	71,630	32,379	69,969	33,812	78,841
- Others	15,047	36,258	31,442	80,887	89,835	217,878
- Unhardened Rubber	78	110	14	23	0	0
Sub-total :	100,944	252,297	144,542	388,522	241,964	602,752
D) Ferrous Metals & Steel						
- Pig or cast iron	340	255	243	200	7,432	7,158
- Alloy steel	426,653	584,766	394,514	517,690	475,186	486,688
- Tinplate	10	20	0	0	0	0
Sub-total :	427,003	585,041	394,757	517,890	482,618	493,846
E) Non-Ferrous Metals						
- Copper & alloys	59,171	665,219	73,136	570,709	115,036	646,087
- Nickel	29	1,044	35	786	43	1,455
- Aluminum	26,678	240,900	26,407	188,122	33,399	182,694
- Lead	1,797	4,390	3,102	7,586	1,840	2,502
- Zinc	3,940	14,393	2,006	4,898	2,015	8,705
- Tin	25	399	40	566	44	693
- Metal ash & residues	2,025	12,778	997	3,957	479	1,553
- Magnesium	0	0	0	0	0	0
- Silver	0.5	539	0	1	1	1,086
- Platinum	0	0	0	0	0	2,193
- Other base metals	0	0	0	0	0	0
Sub-total :	93,665	939,662	105,723	776,625	152,858	846,968
F) Textile Fibres						
- Silk	0	21	5	417	27	1,942
- Cotton	19,243	57,284	14,343	47,624	14,214	36,040
- Man-made fibres	287	1,231	126	558	265	874
- Wool/other animal hair (not pulled)	122	3,330	178	3,810	196	6,863
- Wool/other animal hair (pulled)	0	0	0	0	0	0
- Old clothing & other old textile articles, rags, etc.	15,725	43,907	16,392	49,624	14,922	43,239
Sub-total :	35,377	105,773	31,044	102,033	29,624	88,958
Total :	1,216,945	2,285,156	1,278,616	2,238,829	1,422,904	2,414,912

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