The Australian Waste Database : A Tool for Improving Regional Solid and Hazardous Waste Management

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Abstract

The Australian Waste Database (AWD) has been established by the CRC for Waste Management & Pollution Control Ltd for Environment Australia. It compiles information on urban solid waste and manifested hazardous waste generation, in accordance with uniform national classification systems. This paper analyses trends in manifested hazardous waste generation; and presents an analysis of changes in amounts of urban solid waste streams generated in Australian cities since 1990. It shows how this information can be used by regional waste managers to improve waste minimisation and management.

Investigation of achievement of waste minimisation targets, and trends in waste performance indicators, such as per capita generation rates and per GDP rates, are undertaken for both hazardous and urban solid waste. Inter-regional comparisons are undertaken to point to more effective waste minimisation policies. The influence of economic factors are discussed in this assessment.

Access to AWD information in more detailed form is described in the paper, so that regions and researchers may undertake their own investigations for the purpose of preparing waste strategies and inter-regional comparisons. An Internet site, an email discussion list and hardcopy reports and data are available.

The paper concludes with a summary of how the Database can be used by a range of users to better understand waste generation in their own region, and to be able to identify similar regions that may be achieving better waste minimisation through alternative policies and facilities. It then discusses how the AWD can be improved by becoming part of a broader regional materials management information system.

1 Introduction

1.1 Introduction to the Australian Waste Database Project

The Australian Waste Database (AWD) has been established by the CRC for Waste Management & Pollution Control Ltd (CRCWMPC) for Environment Australia. It provides a centralised compilation of data on solid and hazardous waste generation in Australia, and has been designed to be widely accessible to interested parties. This paper briefly explains the scope and means of accessing data in the AWD, and then provides an

analysis of urban solid waste in Australia, and manifested hazardous waste generation in the three regions of Sydney, Victoria and Adelaide..

A number of institutional changes and increasingly stringent regulations have influenced the data available. Urban Solid Waste data has only begun to be collected in a comprehensive way since the early 1990s in a number of regions. In addition, it will not be possible to consider manifested hazardous waste generation in more than three regions, until the now developing National Environment Protection Council (NEPC) classification system has been finalised and widely introduced. However, in spite of the still developing nature of data collection, the paper provides an overview of the potential for using the AWD and similar national systems for better managing urban solid, and hazardous, waste at a regional and industry specific level.

1.2 Australian Statutory Arrangements

Australia has a a population of 18 million, with more than 80% located in the capital city of each of the eight States and Territories. The States form the Commonwealth of Australia, with laws and services dealing with the environment, education, health, police and the like, being the responsibility of the States, and the Commonwealth being responsible for National issues of defence, trade and taxation. A third tier of government, Local Government or Councils, provide urban solid waste services as well as stormwater, local roads, parks and library services.

In the area of waste management, the role of each level of government is:

- The Commonwealth is responsible for international movements of hazardous waste, and for participating in and providing support for the Australia and New Zealand Environment & Conservation Council (ANZECC) and NEPC, which are composed of the Commonwealth and State Ministers for the Environment. With the assistance of the Environment Australia; ANZECC, NEPC and the Commonwealth government develop national guidelines in a range of environmental areas, including waste management.

- State governments use ANZECC and NEPC guidelines as a common basis for making State laws and regulations which are administrated by State EPAs and Waste Authorities. These encompass licensing of Waste generators and waste treatment plant operators, and enforcement of discharge standards.

- Local governments have responsibility for urban solid waste management, and sometimes also hazardous waste management (which in other cases, is a State responsibility). Collection, recycling and usually landfill disposal of waste is undertaken by a mixture of day labour and contractors.

1.3 International and Australian Waste Policies

A series of Conventions, Regulations and policies in Australia relating to waste management require the collection and reporting of solid and hazardous waste generation data at the international, national, regional and firm level. These are outlined below and are detailed in Moore & Tu (1995).

At the international level, Australia has an obligation to collect and report waste data in accordance with OECD Council decision C(90)178/FINAL of 31st January, 1991 and Agenda 21 recommendations (UNCED, 1992).

At the National and State level, governments as well as industry umbrella groups have established policies that require the monitoring and reporting of waste generation. Government policies and laws include a number of waste to disposal reduction targets and recycling targets.

Industry umbrella groups have also developed policies to guide their members in improving environmental performance. Many of these include requirements for waste generation data collection and monitoring, often associated with the setting of benchmarks and the monitoring of their achievement.

1.4 Need for an Australian Waste Database

It can be seen from this brief review that there is a wide spectrum of requirements for the collection and reporting of information on waste generation and management in Australia; similar requirements no doubt exist in many other countries. The danger in Australia, and internationally, is that, through a lack of coordination and standards, information will be collected in forms that do not facilitate aggregation and comparison across industry sectors, nor across State and National borders.

An examination of the state of waste data collection and reporting in Australia in 1992 highlighted how inadequate systems were in meeting the demands placed on them by the new and developing waste policies described above. There was an urgent need to develop uniform methods of classification, data collection, storage and reporting so that the target setting and monitoring demands of these various government and industry waste policies could be met. In addition, such a uniform system would facilitate cross industry and interstate and international comparisons.

The Australian Waste Database (AWD) project was initiated by the CRC for Waste Management and Pollution Control Ltd and Environment Australia to meet the need for such a system. The primary aim of the project was to establish a database on waste generation in Australia which could be used by State and Federal environmental and waste management agencies, and other interested organisations, to set and monitor the achievement of national waste minimisation targets.

In achieving this aim, the following objectives have been met:

(a) Review and establish nationally agreed classification systems for various groups.
(b) Establish a protocol for sampling and characterising urban solid wastes.
(c) Establish a national waste generation database to provide fundamental information on the generation of different types of waste (urban solid waste and manifested hazardous waste) by region and in relation to relevant parameters.

The establishment phase was completed in June 1995 and ongoing maintenance and development of the AWD is being undertaken by the CRCWMPC for Environment Australia.

1.5 Access to AWD Reports

This paper provides some examples of, and analysis of, a great range of graphical and tabular reports from the AWD. Graphical reports in this paper are intended to show main trends; they are always supported by tables with numerical data in AWD reports. Readers may access the full set of AWD reports produced by the project by :

- Providing their contact details to the authors at the University of New South Wales, Sydney (Ph +612 9385 5073, Fax +612 9385 6139) so that they can be added to a mailing list for a Newsletter. Order forms for Reports, papers and standard hardcopy reports from the AWD are provided with the Newsletter.
- Accessing an Internet WWW site via the Environment Australia Online home page at http://www.erin.gov.au/portfolio/epg/env_sust.html and then clicking on "Waste Minimisation".

2 Waste Classification System and Data Collection

2.1 Introduction

In establishing national waste data collection and reporting systems, it is essential to start with an agreed uniform classification system. As noted above, inter-regional comparisons are impossible without the use of common terminology, and this difficult task should be given high priority early in the establishment of a waste information system. Ideally, classification systems that are consistent with International standards are best, allowing international comparisons. However, local institutional arrangements and procedures may work against this.

An equally important issue is the establishment of mechanisms for data collection in a reliable and uniform manner. Again, local institutional arrangements and regulations will need to be used to design this data collection. In Australia, data is forwarded to the AWD team by State EPAs acting as data co-ordinating institutions. The State EPAs have the regulatory authority to require data to be provided to them in a particular format, usually :

- Amounts of urban solid waste to disposal and some recycling facilities are recorded by facility operators, and data is submitted to the State EPA on a monthly or quarterly basis. Often a levy of up to $10/t is paid to the State as part of this waste amount reporting.
- Composition of urban solid waste streams is determined by organisations interested in developing regional waste strategies and facilities. In addition, State EPAs monitor waste composition to provide information for policy formation and monitoring. This data is provided on a voluntary basis to either the State EPA or the AWD.
- Amounts of waste materials collected from the Municipal Waste stream for recycling by Councils sometimes attracts a rebate benefit of up to about $20/t. Councils submit data on amounts of different materials collected in order to claim this rebate.
- Manifested hazardous wastes are those hazardous wastes transported off the site of the generator to a regional treatment facility. The transport is monitored by a "manifest" system that records date, waste generator, waste type, waste amount and treatment type. The manifest system is normally operated by the EPA, and aggregations of waste type by industry group in different regions can be extracted from the manifest database, and supplied to the AWD.
- Total amounts of recycled materials in the country can most easily be determined from records kept by the relatively small number of companies buying the materials as feedstock for their facilities (paper mills, steelworks etc). This data can be voluntarily provided by these companies as part of a series of Industry Waste Reduction Plans that are being agreed to between industry groups and government.

2.2 Urban Solid Wastes

The classification system for urban solid wastes is in two parts :

- a description of the waste stream's attributes of source, disposal method, weighing method and bulk composition. The amount in tonnes per month for a particular region is the data provided.
- a description of the material composition of the waste streams, using % of material types as the data collected.

An outline of these amount and material composition classification systems are shown in Tables 1 and 2 below. Details are provided in Moore and Tu (1995)

Table 1 : Solid Waste Classification : Waste Streams

Proc./Disposal Route	**Waste Stream Principal Source**	**Sub-stream 1 Secondary Source**	**Sub-stream 2 Measurement**	**Sub-stream 3 Material Composition**
1 Recycling	A: Municipal Waste	1 Domestic Waste	0 Weighbridge	0 Mixed
2 Composting		2 Other Domestic Waste		
3 Incineration		3 Other Council	various truck	various segregated
4 Landfill			types or	material types
5 On-site	B: Comm. & Industrial	O Unknown	topographic	eg, tyres
		A Agriculture	surveys	
		B Mining		
		C Manufacturing		
		D Electricity, Gas and water		
		F Wholesale and Retail Trade		
		G Transport and Storage		
		HIJ Services Sector		
		K Community Services(hlth,ed)		
		L Recreation, Tourism		
	C: Bldg. and Demo.	X Waste Processing Facility		

Table 3 : Solid Waste Composition Classification

Code	**Material Type**	**Material Detail**	**Material Detail Sub-Category 1**
A	Paper	Each Material Type has categories of material type, eg newsprint, cardbaord	Each category may have sub-categories eg packaging, non-packaging
B01	Organic Compostable	Food / Kitchen	
B02		Garden	
B03		Other Putrescible	
C	Other Organic		
D	Glass		
E	Plastic		
F	Ferrous		
G	Nonferrous		
H	Household hazardous		
I	Others		

2.3 Manifested Hazardous Wastes

At a national level, the hazardous waste classification system has been evolving since 1986 when the Australian Environment Council recommended a system (AEC, 1986), which was then introduced in some States. It was revised by ANZECC in 1994 (ANZECC, 1994), and this system was introduced into South Australia. The NEPC is now revising the classification system (NEPC, 1997), and it should be consistent with the UNEP Basel Convention system when finalised late in 1997. Australia uses the UNEP Basel Convention code system or the OECD system when importing or exporting hazardous wastes.

These changes to the classification system, and the current non-uniform application of a hazardous waste classification system between States, has made it difficult to establish a national database which can easily provide inter-regional comparisons. This emphasises the need to establish a uniform system early in the process.

The 17 major waste types used in Sydney, Melbourne and Adelaide in the period 1990 - 1994 are shown in Table 3. Sub-categories for each of these waste types provides a total of over 80 “minor” waste types (eg, sulphuric acid, hydrochloric acid etc). Waste generators are not currently known to the AWD, but the standard industry code that they belong to (on an aggregated basis) is provided by State EPAs. The Australian Standard Industry Code (ASIC) at the one digit, and two digit level for manufacturing, is provided in Table 4.

Table 3 : Major Waste Type Categories (as used in Melbourne and Sydney, 1990 - 1994)

Code	Description	Code	Description
A	Plating and Heat Treatment		
B	Acids	J	Textile wastes
C	Alkalis	K	Putrescible organic wastes
D	Inorganic Chemicals	L	Wash waters
E	Reactive Chemicals	M	Inert Waste
F	Paints, resins, inks, organic sludges	N	Organic chemicals
G	Organic solvents	O	Bags, containers
H	Pesticides	P	Immobilised wastes
I	Waste oil	Q	Miscellaneous

Table 4 : ASIC Industry Codes

Code	Description (1 Digit)	Code	Description (2 digit Manufacturing)
A	Agriculture, Forestry, Fishing, …		
B	Mining		
C	Manufacturing	21	Food, Beverage and Tobacco
D	Electricity, Gas, Water	23	Textiles
E	Construction	24	Clothing and Footware
F	Wholesale and Retail Trade	25	Wood, Wood Products and Furniture
G	Transport and Storage	26	Paper, Paper Products
H	Communication	27	Chemical, Petroleum and Coal Prod.
I	Finance, Property, Business Serv.	28	Non-metallic Mineral Products
J	Public Administration	29	Basic Metal Products
K	Community Services	31	Fabricated Metal Products
L	Recreation, Personal, Oth. Serv.	32	Transport Equipment
M	Non - Classified	33	Other machinery and equipment
		34	Miscellaneous manufacturing

3 Urban Solid Waste Generation Trends

3.1 Urban Solid Waste Reports

Graphical and tabular reports are produced by the AWD on waste streams and the composition of waste streams by region and period. Examples are shown in Figure 1,and Tables 5 and 6, for the Sydney region.

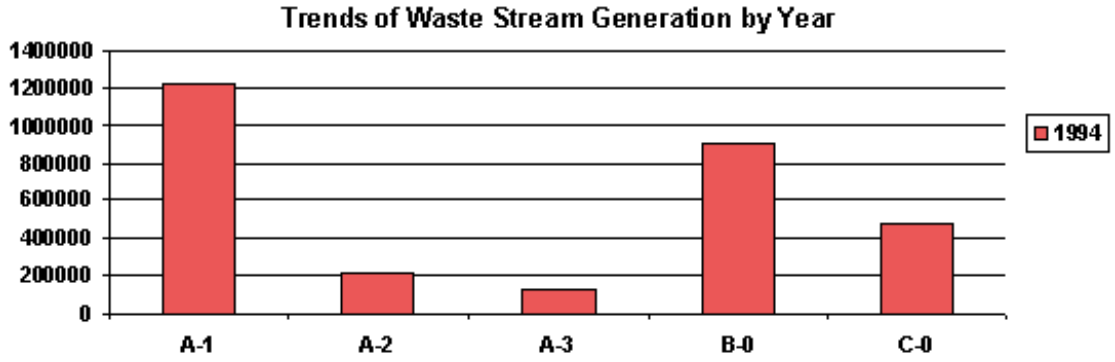

Figure 1 : Waste Stream amounts (tonne) to Disposal, Sydney, 1994 (Refer Table 1 for waste codes).

Table 5 : Amount of Domestic Waste stream materials to recycling, kg/person/year, Waste Regions in Sydney, 1994

Region	Population	Paper	Glass	Plastic	Ferrous	Non-Ferrous	Total
Sydney	3407500	36.2	17.9	1.0	0.1	0.2	55.4
Western	1248250	22.8	12.3	1.0	0.3	0.3	36.6
Southern	948800	42.2	20.0	0.9	0.0	0.2	63.4
Northern	733150	55.2	26.1	1.2	0.1	0.2	82.7
Inner	268250	41.1	21.5	0.9	nil	0.1	63.5
Macarthur	209050	16.2	8.7	0.7	nil	0.1	25.7

Table 6 : Composition of Domestic Waste Stream, Randwick (Sydney suburb), 1994

Material Type	Mean, %	Std Dev	Max	Min	Samples
Paper	23	4.8	29.5	14.9	9
Org Compostable	48	7.6	58.4	37.8	9
Oth Organic	4	1.8	6.7	1.4	9
Glass	6.8	1.7	9.3	4.4	9
Plastic	9.9	2.4	14.7	6.6	9
Ferrous	3.8	1.1	5.2	2.4	9
NonFerrous	0.9	0.43	1.8	0.45	9
H'hold Hazardous	0.3	0.23	0.8	0.02	9
Other	3.3	1.4	5.5	1.3	9

3.2 Urban Solid Waste Generation Trends

Now that data is being collected over a number of years and across regions, a series of trend analyses can be undertaken. Waste generation within a region over time, inter-regional comparisons based on waste performance indicators, and overall trends in waste generation over time, are illustrated in this section.

Waste stream to disposal for Municipal Waste (arising from households) and commercial, industrial, building and demolition waste, for major regions in the State of Victoria, for the period 1992 - 1996 are shown in Figure 2. The early decline in Municipal Waste has resulted from increased recycling efforts by households, but this appears to have now levelled off. Increases in the non-household sector wastes were possibly related to a growth in the economy since 1994, and the recent reduction could be showing the influence of improved recycling in these waste streams.

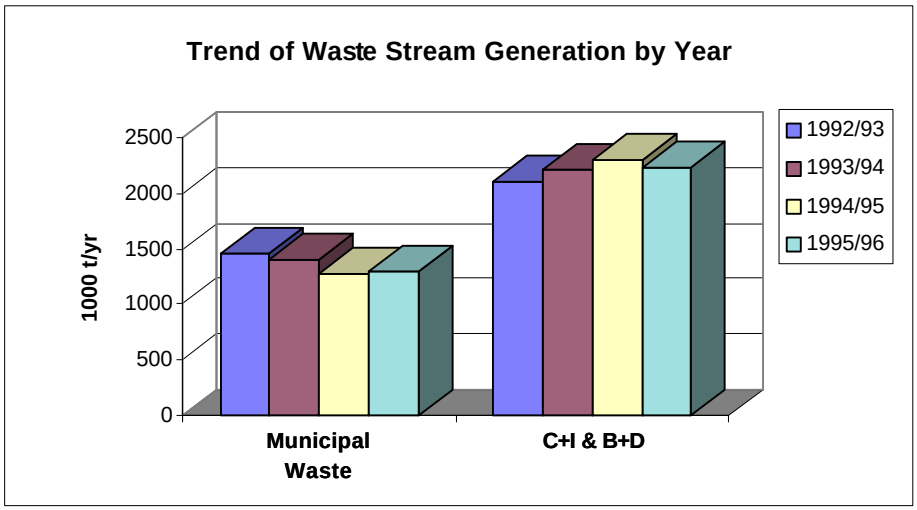

Figure 2: Trend in Waste Streams in major regions in Victoria

Inter-regional comparisons, and comparisons within a region over time, are , however, best undertaken by using indices which take account of increases in population and economic growth. Municipal Waste (from households) is best expressed as kg/person/ day, and because a number of total urban solid waste reduction targets are based on kg/person/day, this index should also be calculated. Commercial and Industrial Waste should take account of economic growth, so that an index of annual kg waste/ annual $100 of State Domestic Product (SDP) illustrate the waste reductions occurring, irrespective of economic recession or growth. Building and Demolition waste should be related to the value of building construction, and an index of annual kg waste/ annual $100 State value of Building Work Done (BWD) is appropriate. These indices assume State and capital city economic growth and building activity have similar trends. Values of these indices for the data available are shown in Figures 3, 4 and 5 below.

Waste to recycling from Domestic Waste is best expressed as kg of material type/person/year, as shown in Figure 7. Total waste to recycling (i.e. including waste from Commercial and Industrial, and Building and Demolition waste streams) is best expressed in an index of the % of material input from recycled waste to total material production, for each material type (paper, steel, aluminium etc). Data for this is currently being gathered.

Figure 3 : Urban Solid Waste (upper data) and Municipal Waste (lower data) indices for regions in Australia.

The Municipal Waste (MW) to Disposal, and Urban Solid Waste (USW) to Disposal indices show differences between regions in Australia (Figure 3), and generally show declining trends except for Sydney's Urban Solid Waste. Economic growth and building activity can influence the USW population based index, and this may account for increases in this index for Sydney; it is therefore necessary to consider economic based indices for the Commercial and Industrial, and Building and Demolition waste components of USW. The Municipal Waste indices indicate that the ACT has introduced a waste management system which provides the lowest per capita generation rate, and other regions should seek to learn from the experience of the ACT. Overall, Adelaide also appears to have made good reductions in per capita USW to disposal rates, but details of the effect of economic and building activity on non-household waste generation will need to be analysed before a full analysis of this trend could be made.

Figure 4 : Commercial and Industrial Waste index

The index relating Commercial and Industrial Waste to Disposal, to economic conditions expressed in State Domestic Product, shows that waste generation rates have declined by 40% in Sydney. At the same time economic growth at 2- 5 % p.a. over the period (except for 1990/91 to 1991/1992 with a recession of 0.4%, when per capita C&I also declined) has been greater than population growth of less than 1.5% p.a.; hence showing that waste reductions against a prime causative factor (economic conditions for Commercial and Industrial waste) can show up as an apparent increase against a causative factor of lesser importance (population growth).

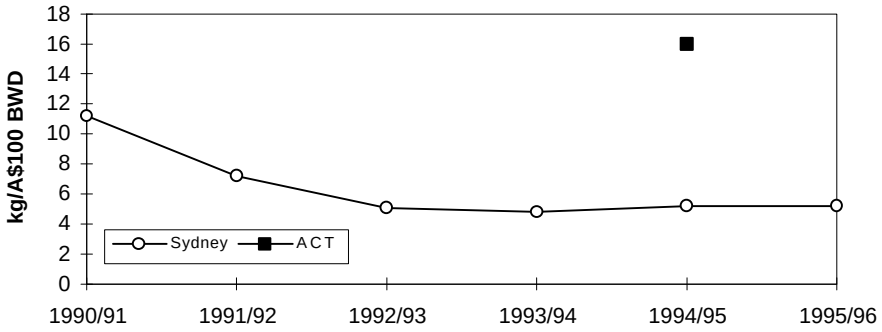

Figure 5 : Building and Demolition Waste Index

The Building and Demolition waste index shows a reduction in the rate in Sydney, to a rate much lower than Canberra. Increased recycling at Demolition sites in the early 1990s has possibly accounted for this reduced rate. Again, the increase in overall Building activity at a rate greater than population growth, can explain the improvement in waste minimisation for this component of USW, while overall USW as a per capita rate appears to be increasing.

The incomplete picture shown by per capita rates is illustrated in Figure 6 below. For Sydney, it shows worsening of both C&I and B&D per capita rates over the period, leading to the overall worsening of the USW per capita rate. However, the above analysis clearly shows dramatic improvements in waste to disposal rates for these two waste streams, when they are viewed in terms of the factors leading to their occurrence.

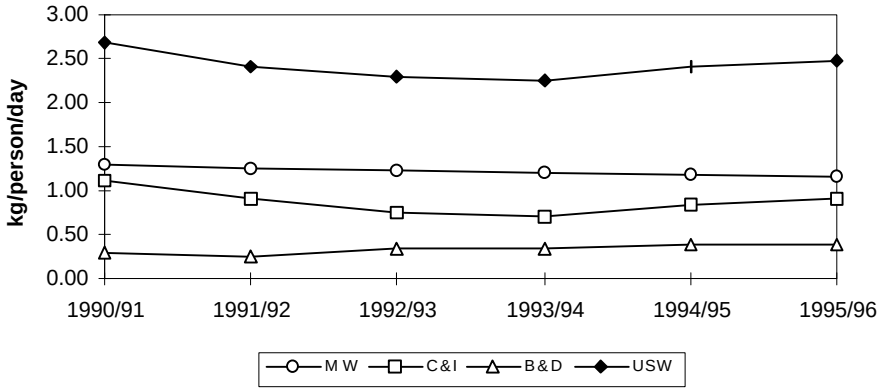

Figure 6 : Sydney Per Capita Waste to Disposal Rates

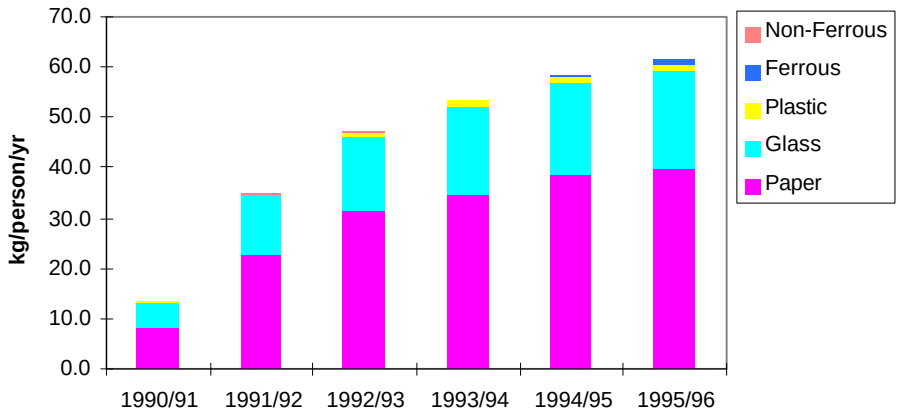

Figure 7 : Domestic Waste Recycling Index, Sydney

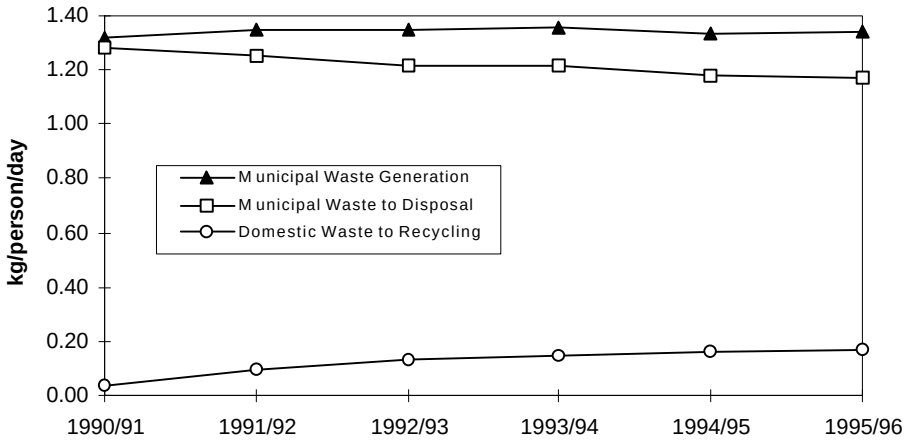

Figure 8: Domestic waste to recycling, Municipal Waste to Disposal, and Municipal Waste Generation , in Sydney.

Figures 7 and 8 show Domestic Waste to recycling per capita rates, by material type and as a proportion of Municipal Waste per capita rates. Data for C&I and B&D waste to recycling are not available, but Figure 8 shows total Municipal Waste Generation as reported by Municipal Waste to disposal plus Domestic Waste to recycling. The figures show that Domestic Waste to recycling has increased substantially, but is a small proportion of overall USW, and Municipal Waste, to Disposal. Municipal Waste Generation has remained static to slightly increasing, indicating that only recycling and not waste avoidance has contributed to reductions in Municipal Waste to disposal. With anecdotal information that C&I and B&D waste to recycling has increased in the early 1990s, USW generation has probably also increased to a greater extent than USW to disposal rates since 1993.

The indices provide a better understanding of waste generation and recycling patterns. As has been shown with the C&I and B&D indices, indices must be related to the causative factors of waste generation, otherwise trends appear that do not explain the full situation.

4 Manifested Hazardous Waste Trends

4.1 Manifested Hazardous Waste Reports

Reports can be provided from total manifested hazardous waste generation by region and period at the general level, down to the amount of each of the 80 categories of waste type produced by each 4 digit ASIC industry group, by region and period. These reports are illustrated and commented on in this section, and further analysis is provided in Section 4.2. The waste type categories can be aggregated to major waste types, as shown in Table 3, and ASIC industry codes are provided in Table 4.

Examples of the reports are provided in the following tables and figures.

Table 7 provides a summary of the total manifested hazardous waste produced by region and period from 1990 to 1994. The large increase in Sydney in 1993 and 1994 was mostly due to large amounts of Miscellaneous waste, probably arising from contaminated soil removal.

Table 7 : Manifested Hazardous Waste Generation by Region, 1990 - 1994, t/yr

Region	1990	1991	1992	1993	1994
Sydney	84 787	62 329	60 152	202 042	213 218
Victoria	158 339	203 992	409 038		
Adelaide	37 184[1]	37 589[1]	39 054[1]	108490	98 904

Notes : (1) This data does not include the manifest system covering small generators, contributing about 40 000 t/yr .

Within a region it is possible to provide a table and graph of each manifested hazardous waste generated by major industry type (1 digit in Table 4) and, separately, by 2 digit industry type within the Manufacturing sector. These tables and graphs indicate that the manufacturing sector is the largest generator, but that significant amounts also arise from hospital/pathogenic waste and from contaminated soil removal (eg, Figure 9). Within the Manufacturing sector the major generators are the Chemicals, Petroleum and Coal related Products; Food and Beverages; the Basic Metal Products; and the Fabricated Metal Products industry types (eg, Figure 10).

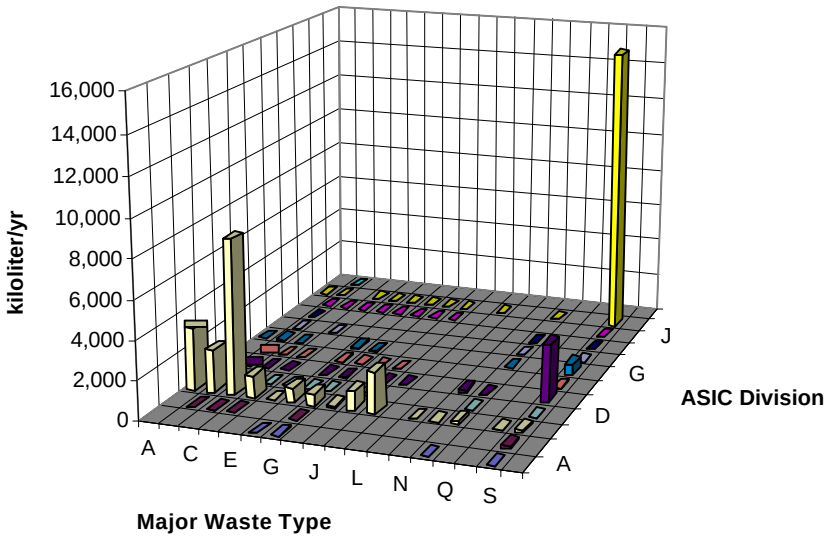

Figure 9 : Total Manifested Hazardous Waste Generation by 1 Digit Industry Types, Adelaide 1992

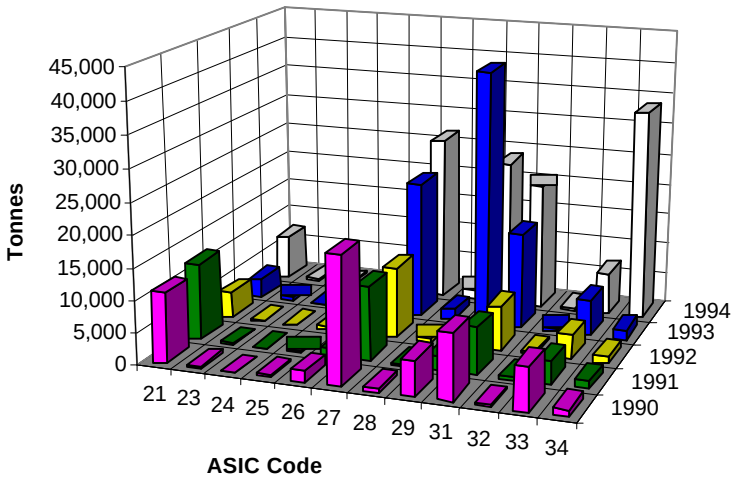

Figure 10 : Total Hazardous Waste Generated by 2 Digit Manufacturing Sectors in Sydney, 1990 - 1994

Examination of major waste types generated by 2 digit ASIC industry groups (eg, Figure 11) shows the major generators as described above, and indicates that the major waste streams generated in terms of amount are usually acids, alkalis, organic sludges, oily wastes and putrescible sludges (grease trap waste). Life Cycle Assessment and other materials accounting techniques are attempting to prioritise these waste amounts in terms of environmental importance, related to ecotoxicity and associated materials and energy requirements of the materials in the waste streams.

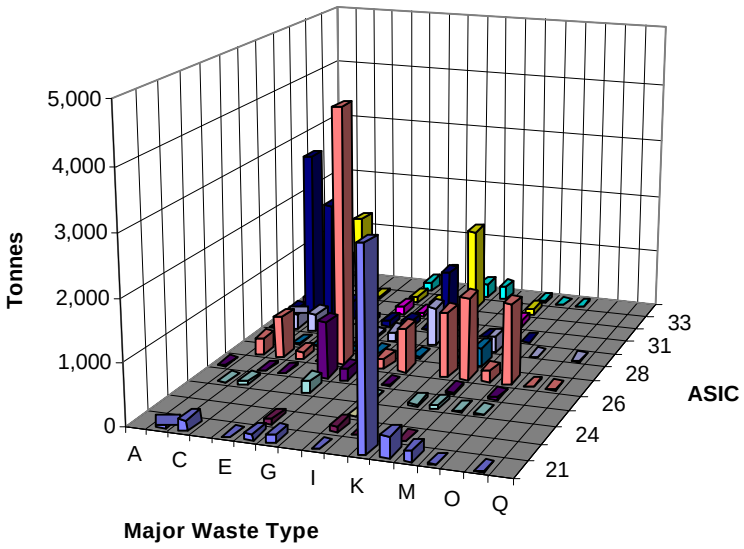

Figure 11 : Major Waste Type from 2 Digit Manufacturing Industries, Sydney, 1992

Other special reports by waste type, and by industry type, can be prepared by the AWD on request. Detailed data on the 2 and 4 digit ASIC industry types producing certain wastes, and details of the 80 category minor waste types produced by 2 and 4 digit ASIC industry codes can be produced. These are helpful in designing waste minimisation programs at the regional and industry level, and can be used by industry to track waste reduction trends over time.

4.2 Inter-regional Comparison of Manifested Hazardous Waste Generation

Section 4.1 has provided a series of reports that can be used at a regional level, or at an industry level within a region, to develop and monitor improved manifested hazardous waste management. When combined with other waste reports, as proposed in the National Pollutant Inventory, improved waste and environmental management at a regional level should be facilitated.

In this section, the use of the AWD for inter-region comparison is considered. Different regions have a different range of causative factors for hazardous waste generation, related to the industry profile of the region; and also have variations in the methods used at regional and industry levels to manage wastes. If the variations in causative factors can be included in an index, then the effectiveness of different methods of control at regional and industry level can be better understood, and can be used for the ongoing development of better programs. Such an analysis is provided in detail in Moore and Tu (1995) and is summarised below.

The Fabricated Metal Products industry is used as an example, and a comparison of employment at the three digit level (e.g. Sheet Metal Products etc.) shows a similar industrial profile in the Sydney, Melbourne and Adelaide regions. The hazardous waste performance index chosen is litres of each major waste type produced per employee and

year, in the Fabricated Metal Products industry group, in each of the three regions studied as summarised in Table 8.

Table 8 : Fabricated Metal Products Hazardous Waste Generation, L/employee and year.

Adel Pre 1993	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**J**	**K**	**L**	**M**	**N**	**P**	**Q**	**R**	**S**
Syd + Melb	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**
Adelaide Average	154	224	153	45.7	0.0	23.5	6.6		93.2			0.1	1.2	0.0		240	133
Sydney Average	4.4	113	101	17.5	2.2	7.2	11.6	0.6	55.1	7.0		2.9	4.1	0.3			
Melbourne Average	5.2	49.3	27.1	2.1	1.1	10.3	1.2		27.1	0.2	5.5	5.4	9.3	0.3	0.9	0.7	41.0

Before attempting to interpret the data, it is necessary to note a number of factors which may make the comparison of the data difficult :

- There is no detailed guideline on how to use the Waste Type categories, and each region may use a different method of assigning the waste type code to a particular waste;
- The industry profile may exhibit some significant differences at the four digit level of detail
- At times, Sydney has also accepted manifested hazardous waste from outside the Sydney Statistical Division area;
- An inherent problem with this employment based index is that it does not directly account for improved labour productivity, which would indicate an increase in the waste index which would not be associated with an increase in waste per product. Unfortunately data on product amount per industry sector is not readily available.

Having regard for the above factors, points of interest from the analysis in Table 8, from the perspective of improving regional waste and environmental management, are :

- Overall manifested hazardous waste generation in Sydney is about a third of Adelaide, and in Melbourne about a tenth of Adelaide. Assuming a similar industry structure at the four digit ASIC level, the relatively low price of off-site hazardous waste treatment and disposal in Adelaide up to the end of the 1980s could provide some explanation for the relatively large amount apparently still being disposed to off-site treatment there. In terms of planning a regional waste minimisation strategy, it would suggest that a more detailed investigation of the four digit ASIC industry structure (components, number of employees per component, and size of components) be undertaken to determine whether there is in fact potential (and whether it is desirable) to reduce waste generation in this manifested hazardous waste area.

- In order to make a comprehensive investigation, it would be desirable to have data on other waste quantities (to sewer, to on-site disposal and to urban solid waste disposal), and on a normalising factor independent of labour productivity, such as product amount. It is suggested that the National Pollutant Inventory consider these issues in the development of its guidelines.

5 CONCLUSIONS AND FUTURE DEVELOPMENT OF THE AWD

The analysis in Section 4 has shown that, even with a good data collection mechanisms in the Urban Solid Waste and in the manifest system for hazardous wastes, there are still significant problems that arise when the data is analysed and tried to be used for improved environmental management at a regional level. The production of reports from the AWD, and their use in regional environmental management, will lead to an improvement in the quality of data via positive feedback mechanisms; and, in conjunction with the proposed National Pollutant Inventory, will contribute to providing a useful tool for environmental management, namely :

- Monitoring achievement of waste reduction and recycling targets.
- Identification of regions apparently performing better through the waste performance indicators, which attempt to normalise population and industrial size differences, so that inter-regional comparisons can be undertaken.
- Provision of information on waste amounts and characteristics for design of regional waste infrastructure and systems.
- Indications of the relationship between waste generation and the state and structure of the economy, particularly for those waste streams related more to economic activity than population.

While this information is a useful tool for improving regional waste management, concentration of monitoring resources only on waste outputs and ambient environmental quality will only provide a (very good) understanding of the problem after it has manifested itself in the monitoring data. Authorities and institutions then need to *react* to remediate the now identified problem, and to change the system so that the problem does not continue to occur. Experience has shown that this may take 30 years in the case of problems that can be remediated, while in some cases remediation may not be possible.

We need to move towards developing an understanding of the whole of material flows in a region in order to know which input goods are significant, where the stocks of certain materials are accumulating (for possible future disposal as waste or as a resource), and where both current *and future* waste emissions will arise under different materials management scenarios. We can then design materials management systems to most efficiently satisfy the dual objectives of controlling emissions and conserving resources.

In this broader perspective, sustainable waste management can be seen as control (minimisation, treatment and disposal) of emissions to within environmental protection limits and an appropriate contribution to conservation of resources (Brunner & Baccini,

1992). To do this in a sustainable way, we must go beyond managing waste materials as a separate system, and move towards managing materials as a whole in regions. In order to do this, we need to extend beyond waste accounting and to develop materials accounting systems at a regional level.

Of course, environmental quality monitoring and waste emission monitoring will need to be continued, but they need to be directed to answering questions that can only arise from a more holistic understanding of our use of materials in regions, questions directed at anticipating future problems and opportunities, instead of merely confirming often obvious environmental degradation. The AWD project has attempted to do this and will move on to the development of regional materials accounting systems that accept data from the AWD reports.

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