Recycling and disposal of plastics waste in South Africa

R H Nurse, N C Symington, G R de V Brooks, L J Heyl

A report of the Committee for Solid Wastes
National Programme for Environmental Sciences

SOUTH AFRICAN NATIONAL SCIENTIFIC PROGRAMMES REPORT NO

6

JUNE 1976

Compiled and issued by the
National Scientific Programmes Unit
Council for Scientific and Industrial Research
P O Box 395
PRETORIA 0001
from whom copies of reports in this series are available on request.

Printed 1976 in the Republic of South Africa
by the Graphic Arts Division of the CSIR

ISBN 0 7988 0931 0.

REPORT ON ACTIVITIES OF THE COMMITTEE FOR SOLID WASTES

Report on Recycling and Disposal of Plastic Wastes in South Africa

The main findings of the report were:

- Only the main thermoplastic types (high and low density polyethylene, polyvinyl chloride, polystyrene and polypropylene) are recyclable. These plastic types represent 67 per cent of the total consumption of plastics in 1974.
- Approximately 130 000 tons of plastic waste generated in 1975 was available for recycling.
- Economic gain for the recycler is the strongest motivation for recycling. Resource conservation, reduction of waste disposal costs and ecological considerations are less important factors.
- Approximately 15 000 tons, or 12 per cent, of recyclable plastic is currently being recycled. A growth rate in recycled plastic of 12,5 per cent per annum is expected until 1981.
- Due to the fact that plastic wastes provide no special problems in currently used waste disposal systems, it is concluded that there is no need for further research directed specifically at the disposal aspect of plastic in urban waste.

CURRENT TITLES IN THIS SERIES

1. A description of the Savanna Ecosystem Project, Nylsvley, South Africa. December 1975. 24 pp.

2. Sensitivity analysis of a simple linear model of a savanna ecosystem at Nylsvley. W M Getz and A M Starfield. December 1975. 18 pp.

3. Savanna Ecosystem Project - Progress Report 1974/1975. S M Hirst. December 1975. 27 pp.

4. Solid wastes research in South Africa - A report by the Committee for Solid Wastes. R G Noble. June 1976. 13 pp.

5. Bibliography on marine pollution in South Africa. D A Darracott and C E Cloete. June 1976. 131 pp.

6. Recycling and disposal of plastics waste in South Africa. R H Nurse, N C Symington, G R de V Brooks and L J Heyl. June 1976. 35 pp.

7. South African Red Data Book - Aves W R Siegfried, P G H Frost, J Cooper and A C Kemp. June 1976. 108 pp.

PREFACE

The National Programme for Environmental Sciences aims at identifying, evaluating and working towards solutions for environmental problems through cooperative studies drawing together interested scientists from various sectors. Apart from solid wastes, the National Programme also includes research relating to ecosystems, their structure, functioning and exploitation and disturbance by man. It includes research relating to environmental problems in inland waters, terrestrial ecosystems, the sea and lower atmosphere. It includes research designed to meet local needs as well as projects being undertaken in South Africa as contributions to the international programme of SCOPE (Scientific Committee on Problems of the Environment), the body set up in 1970 by ICSU (International Council for Scientific Unions) to act as a focus of non-governmental international scientific effort in the environmental field.

This report was drawn up at the request of the Committee for Solid Wastes as part of it's responsibilities on behalf of the National Programme for Environmental Sciences.

The objective of the report is to describe plastic waste disposal and recycling practices and potential in South Africa.

It is the result of a survey of South African recycling practice and plastic consumption patterns, drawing on overseas experience and on opinions of South African conditions. There is a lack of information on the total South African waste generation pattern and on disposal practice. The full extent to which plastic recycling is responsible for reduction and foreign exchange in resource usage, could not be established.

The report starts with a resumé of South African consumption of plastics, including information on applications, time before disposal, and volume of plastics waste generation. It is followed by discussion on the recyclability of plastics waste, leading to consideration of the desirability of recycling. The results of a factual and opinion survey of South African plastics recycling practice are presented, followed by a discussion of the role of plastics in mixed urban refuse. The report is concluded by information on overseas developments.

TABLE OF CONTENTS

THE CONSUMPTION AND APPLICATION OF PLASTICS IN SOUTH AFRICA

South African plastics consumption

The plastics produced and consumed in South Africa may be roughly divided into two groups, namely Thermoplastics and Thermosets. Thermoplastics are by far the larger group, and comprised 79 per cent of total plastics consumption in 1974. There are essentially five basic types of thermoplastic. It is from these, or from the processes by which they are made that many other types of plastics are derived. The five are :

Polyethylene (high and low density - HDPE and LDPE)

Polyvinyl chloride (PVC)

Polystyrene

Polypropylene

The first four are derived from ethylene, and polypropylene from propylene.

The plastics materials comprising the mass of polymers consumed are currently derived mainly from petroleum feed-stocks and to a lesser, but increasingly large extent, coal feed-stocks. Chemically, they are combinations of the basic elements carbon and hydrogen (polyethylenes, polypropylene and polystyrene), while PVC contains 57 per cent by mass of chlorine. They are all relatively inert chemically. They do not dissolve in water, but do melt at temperatures between 110^{o}-$280^{o}C$. They all burn to produce carbon monoxide, carbon dioxide and water, while PVC also produces hydrogen chloride. They do not rot by the biological action of micro-organisms, unless specifically designed to do so. Their mechanical properties are adversely affected by excessive exposure to sunlight. Incorporation of ultra-violet light stabilizers retards this process.

Figure 1 gives an indication of the contributions of some plastics types to the total use pattern.

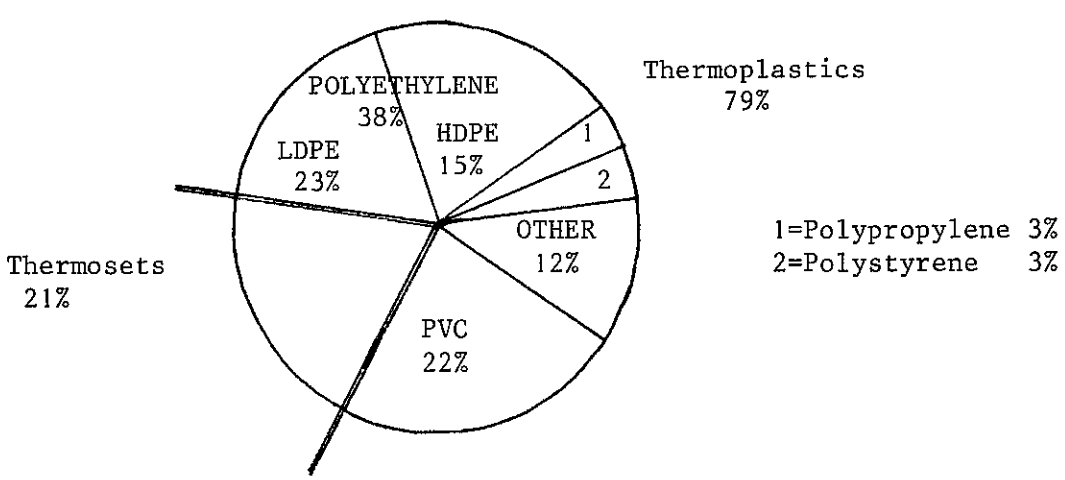


Figure 1. Analysis of plastics consumption (1974).

It will be shown in following chapters that the five main thermoplastic types mentioned are the only forms of plastics amenable to easy recycling. It is for this reason that discussion of consumption volumes and applications will be centred on these. With the exception of disposal through incineration, the behaviour of the different types of plastics in disposal systems is fairly uniform. Table 1 shows the experienced and expected changes in volumes of consumption in South Africa of some plastics types.

Table 1

South African consumption of some plastics ('000 t*)

Year	LDPE	HDPE	PVC	Polystyrene	Polypropylene
1974	101	67	95	14	13
1976	85	43	70	20	14
1978	113	49	92	24	16
1980	150	55	120	29	19

Figures for 1974 are for apparent consumption and are unusually high due to the extensive stock build-up which occurred during that year.

Projection of consumption volumes beyond 1980 would be pure speculation, and very little value could be attached to such guesses. It is, however, apparent that at the beginning of the 1980's, world-wide ethylene and PVC shortages could occur, due to a reluctance during the 1973/74 oil crisis to invest in crackers and downstream plastics plants. The AE&CI and Sentrachem Coalplex project (100 000 tpa PVC by 1978) and Sasol II (300 000 tpa ethylene by 1981) should ensure that no serious shortage will be experienced in South Africa at that time.

Applications

It has been estimated that approximately 70 per cent of polyethylene consumption is used by the packaging industry, the remainder being used chiefly for piping, blow moulding and cables. About 36 per cent of polystyrene and 10 per cent of PVC is used for packaging. In Table 2 some of the applications of the five main thermoplastics as well as an indication of the time elapsing before disposal of the end products for which they are used, is given. It is at the end of this time that the plastics used become part of the solid waste stream.

---

* t = metric tons

This applies to the report as a whole.

Table 2

Plastics application areas and disposal pattern in South Africa (1974)

Plastic type	Applications	Years before disposal ('000t)		
		0-1	0-5	5+
LDPE	Films, Coatings	68		
	Mouldings, Bottles	10	3	
	Cable			12
	Pipe		4	4
HDPE	Closures, Containers	16		
	Film	10		
	Mouldings		16	6
	Pipe, tapes, Twine	2	12	5
Polyproplene		6	6	5
Polystyrene and related plastics)	Trays, Packaging	5		
	Kitchenware, Fittings, Furniture		5	4
PVC	Sheet and film	2	9	10
	Mouldings : bottles, footwear, records and miscellaneous	8	8	1
	Film, cables and wire, flexible extrusions, rigid pipe, sheet, belting	2	5	50

Appendix A shows applications and time before disposal of a more complete list of plastics types. Figure 2 is a summary of the times before disposal of the four main thermoplastics, of other plastics and of all plastics.

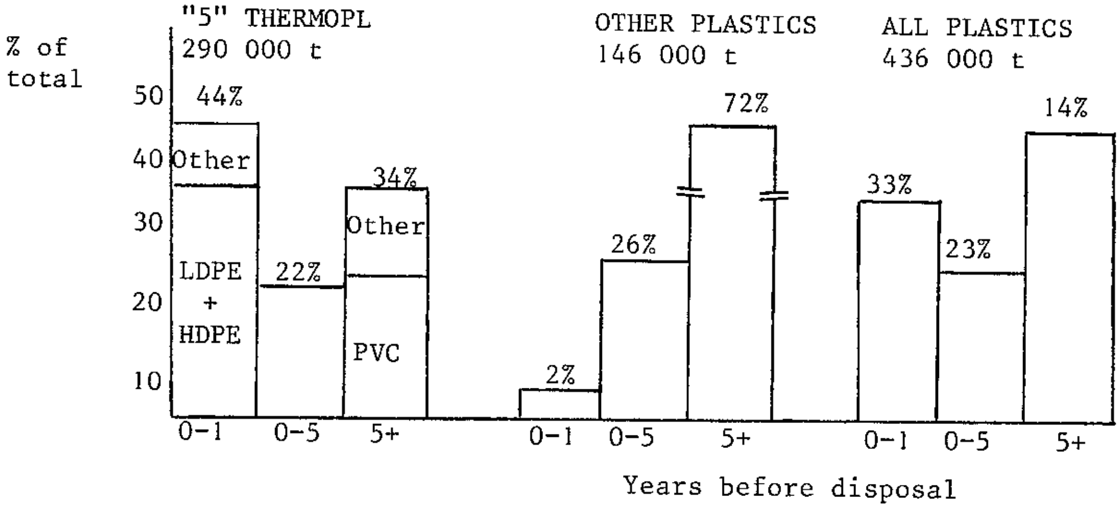


Figure 2. Time before disposal of some plastics (1974)

It is apparent that LDPE is far and away the largest contributor to the disposable (0-1 year life) category, with HDPE and PVC making smaller contributions. It is significant that of the total demand of 436 000 t, 33 per cent, or 144 000 t is discarded in the short term.

The role of plastics in solid waste

In the long term, virtually all plastics consumed will become solid waste. If both the annual consumption of plastics and the time before disposal were constant, then the break-down and volume of plastics waste in terms of plastics types would be identical to that of the annual consumption. These conditions do not prevail, since plastics consumption has been growing very rapidly during the past ten years and the use of plastics for packaging and other applications in which waste is created in less than five years, has been growing faster than the more durable applications. Accordingly, current plastics waste generation is very different to current plastics consumption, and the fraction of waste generated that has been in it's end product form for five years or less is considerably greater than the 56 per cent shown in Figure 2. It is difficult to estimate accurately what that fraction is, but it is probably close to 80 per cent. Anything up to 50 per cent of current plastics waste has been in end product form for one year or less. In Appendix B, a method of determining the nature of current waste is shown. This analysis is of importance if a reasonably accurate estimate of the fraction of recyclable plastics waste that is actually recycled is to be made (see Chapter 4).

Plastics waste is a very small part of total solid waste generation. In the section on recycling in South Africa it is shown that most industrial plastics waste is either recycled on the spot, or sold to trade reprocessors. The plastics component of urban solid waste (comprising commercial and domestic solid waste) varies from place to place. In metropolitan areas, it is probably close to five per cent (Bolitho 1975). At five per cent plastics component, total plastics waste in urban refuse is about 125 000 t per annum.

RECYCLABILITY OF PLASTICS WASTE

Definition of recycling

There are a number of ways of re-using waste plastics. Among them are the following :

Re-use in original product form

Reprocessing to create a new raw material

Energy recovery

A plastics object in it's original form can be re-used in at least two ways. The first is to re-use it for the same purpose as that for which it was originally made. If this is done through a formal system, then the object was never really waste, and only becomes waste once it leaves the system. If this is not done through a system (such as is the case with non-returnable glass wine bottles which are re-used), then re-use temporarily delays the entry of that object into the solid waste stream. The second way in which plastics objects can be re-used in their original form is in a different application to that for which it was originally intended. An example here is plastic bags used in a supermarket which may be re-used by the customer as a freezer bag. Again, the entry of the object into the solid waste stream is only delayed.

Plastics waste can be reprocessed to create a raw material for the manufacture of a new plastics product. Examples of waste plastics products are agricultural film, building panels and pipes.

Incineration of plastics waste is the third option. With a heat of combustion value (ΔH_c of between -330 and -500 (Kcal/mole) at least five times that of coal, and at least twelve times that of general refuse, plastics are a very efficient source of energy supply.

Although the first and third ways of re-using waste plastics mentioned above may, by some, be regarded as recycling (as are landfill and composting), only the second way will be regarded as being recycling for the purposes of this report.

Sources of recyclable plastics

The following are some sources of plastics waste :

Waste generated during conversion of plastics

Mixed urban refuse

Plastics waste separated at source

Dispersed sources

It has been noted that most waste generated during conversion of plastics (in-plant waste) is re-used, either by the converter himself or by trade reprocessors. Where in-plant waste is re-used in the same process as that from which it originated, such re-use should not be regarded as recycling, but rather as an extension of the process itself. The re-use of in-plant waste by trade reprocessors represents recycling in the true sense of the word. This recycling is carried out under what could be regarded as ideal circumstances, since they comply with all four of the following proposed technical criteria for effective recycling :

1. Easily identifiable waste (in terms of the nature of the polymer)

2. Localized waste generation

3. Uniform polymer use

4. Known time since conversion

Plastics comprise between three and five per cent of urban refuse. Separation of plastics from refuse is generally only feasible as part of a total operation of segregation of mixed waste components. Besides the fact that such a total operation has not yet been proved to be economic in South Africa (although some success has been achieved in the USA), isolated plastics are mixed and not easily separable and are (in terms of polymers) not readily identifiable (Henstock 1975).

In addition, the time since conversion, and therefore the degree of degradation of ultra-violet sensitive components, is indeterminate. According to the criteria set out above, recycling of plastics waste from mixed urban refuse is not an attractive proposition.

A number of the shortcomings of recycling from mixed urban waste are overcome when plastics waste is isolated at the source of generation. In the recycling of plastic milk bottles, or of fertilizer bags, for example, waste generation is localized and polymer content, as well as degree of exposure to sunlight, is known. Technically speaking, therefore, recycling is an attractive proposition. The chief constraint, and an additional criterion, on recycling is consequently the ease with which the plastics waste can be transported from source of generation to the reprocessing plant. Plastics waste, having a high value-to-mass ratio, is more suited to separation at the source of generation than any other of the main material types occurring in waste, where transportation costs can be prohibitive.

The collection of plastics waste from dispersed sources includes collection from litter, and from concentrations smaller and less controlled than those utilized in separation at the source. Besides the fact that logistical problems are compounded, only the first of the technical criteria is met, and then not always. Dispersed sources are most unsatisfactory for recycling, and an otherwise recyclable plastics type could be regarded as unrecyclable should it occur as waste only at dispersed sources.

From the above discussion, it is clear that in-plant waste is the ideal source of raw material for recycling activity. Collection of plastics waste which has been separated at the source of generation is also attractive, although logistically more difficult. No immediate possibility of collection of waste plastics from urban refuse or other dispersed sources is seen, although the institution of total segragation of urban refuse could make large quantities available for recycling.

Recyclable plastics

As their name implies, the group of plastics known as thermosets, once formed into an object, cannot be melted and reformed. This, coupled with the fact that in 91 per cent of their applications, the time before disposal is greater than five years, makes thermosets for all intents and purposes unrecyclable. Except in some special cases, the length of time before disposal of plastics provides an indication of the degree to which sources of eventual waste generation will be dispersed. The longer the time before disposal, the greater the dispersion of waste generative sources is likely to be. As was shown in the previous section otherwise recyclable plastics are rendered practically unrecyclable by virtue of their being available only at dispersed sources of generation as waste.

The five main thermoplastic types already mentioned are easily melted and reformed, and are therefore technically speaking, recyclable. A large proportion (45%) of their consumption is in applications in which waste is generated within one year. This, together with some of the waste generated after a period of up to five years, represents the recyclable portion of the five main thermoplastic types. Thermoplastics becoming waste after five year are not easily recycled, due to degrading through mechanical property failure and long use before disposal. Assuming, then, that half of the waste generated after a period of one year and none of that generated after five years, is recyclable, the total tonnage of recyclable waste from this source was (according to Appendix B), approximately 131 000 t in 1975.

Why recycle?

A number of reasons for the desirability of recycling have been put forward. The following four are considered to be the most important :

Reduction of total waste disposal cost

Reduction of pollution

Recovery of scarce resources

Economic gain for the recycler

The total waste disposal cost is assumed to include only those costs incurred by the body normally responsible for waste disposal. Although no figures are available, it is doubtful whether collection of plastics waste from in-plant sources or through separation at the source reduces total disposal costs to any appreciable extent. The cost of waste disposal is insensitive to small variations in volumes disposed of. Figures based on USA experience (Midwest Research Institute 1973) show that the net operating cost of a system for recovery of materials from mixed urban waste (\$4,00 per t) is greater than that for sanitary landfill (\$2,20 per t). There is at present no reason to believe that this cost relationship will be significantly different for South Africa. When landfill sites are situated at a considerable distance from the waste generating area, as is to be the case in Cape Town, the relationship could well change. It appears that recycling of plastics waste cannot be justified on the grounds that total waste disposal costs may be reduced.

It was noted in the section on South African plastics consumption that plastics are all relatively inert chemically. They do not dissolve in water, and therefore do not contribute to the problem of water pollution resulting from solid waste-derived leachates. Products of combustion are carbon monoxide (CO), carbon dioxide and water, as well as hydrogen chloride (HCl) in the case of PVC. CO and HCl are toxic pollutants. Elimination of plastics from solid waste through recycling would not affect CO and HCl levels significantly, since very little incineration or burning of mixed refuse is conducted in South Africa.

The majority of recyclable plastics are produced from an ethylene base. Just over 42 per cent of recyclable plastic consumption is imported directly, while most of the ethylene used for the remainder is derived from imported naphtha. Without considering actual cost figures, it is clear that the less plastics that South Africa imports, and therefore the less foreign exchange expenditure, the better. Recycling, which is currently re-using about 12 per cent of recyclable waste generated (see Section on recycling in South Africa) is reducing the import bill to a certain extent. It should be remembered that only where a plastic product made of virgin material, is replaced by a product that is made from recycled material, is any saving in the amount of plastic imported made. Where a product is made of wood, or metal, or paper or any other locally available material, or where recycled plastic has created a market which would disappear with it, then no reduction in plastics imports is brought about. The extent to which plastics recycling, as practised in South Africa at present, saves foreign exchange is unknown, and it would require detailed study to arrive at any reliable estimate. Calculations of energy and feedstock savings in terms of oil equivalents (TOE - tons of oil equivalent) are subject to the same reservations as those set out for foreign exchange savings.

The fourth motive for recycling plastic waste is the economic gain to be had by the recycler. Despite a number of complaints voiced by dealers and recyclers (see "Recycling in South Africa"), the fact that they exist in large numbers, and that as much as 15 000 t of plastic waste per year is recycled, is an indication that the recycling of plastic waste is profitable.

Economic gain for the recycler appears to be the strongest motivation for recycling. It's desirability cannot be justified in terms of reduction of waste disposal costs or on ecological grounds alone. Further study is necessary to determine to what extent recycling of plastics waste reduces resource consumption in the South African context.

RECYCLING IN SOUTH AFRICA

The structure of the industry

The plastics recycling industry in South Africa consists of three levels. They are : waste dealers, trade reprocessors and waste converters.

Waste dealers

Plastics waste dealers collect plastics waste, normally waste products (as distinct from in-plant waste), and sell it to trade reprocessors or waste converters. In most cases no physical changes are made to the product except that it is compacted and baled. These firms are normally one-man concerns and in most cases the collection of plastics waste is done as a sideline. Most waste dealers are transport contractors and waste collection is seen as secondary to the overall operation of the firm.

Plastics waste is obtained on a contract basis from trade and manufacturing concerns, and to a lesser extent from municipal dumps. Plastics waste dealers obtain some of their plastics waste from waste paper dealers. The impression was gained that the latter have a more efficient collection system. Plastics waste collectors only cover the more important sources such as bottling companies where big quantities of shrink wrap are available. It does not pay them to recover from smaller sources and here they rely on paper waste collectors.

Because plastics waste collection is done as a sideline, in many cases by private individuals, the supply of plastics waste to reprocessors and converters is erratic. Except for a few fairly established firms, waste collectors come and go and this to some extent disrupts the continuity of supply. One of the largest plastics waste collecting firms on the Reef indicated that they will concentrate on their transport activities when the economy again warrants the move.

One reprocessor mentioned that of the four waste collectors supplying him with waste plastics in 1974/1975, only one is still in operation. This of course complicates production planning at converter and reprocessor level.

The Plastics Recycling Association has laid down prices for the supply of plastics waste to their members. The current prices are as follows :

Low density polyethylene (LDPE)

- Grade A Perfectly clean unprinted plastic regardless of colour, normally factory waste. R100 per t.
- Grade B Slightly dusty and printed - for example shrink wrap and fertilizer bags. R70 per t.
- Grade C All other qualities. R50 per t.

High density polyethylene (HDPE)

- Grade H Natural colour bottles and unprinted film. R125 per t.
- Grade I Uncontaminated lumps, crates and heavy containers. R100 per t.

Grade J Uncontaminated coloured bottles. R50 per t.

Grade K Printed film and all other qualities - retail shopping bags, etc. R20 per t.

All of the above are suggested maximum prices. Waste collectors are allowed a further R25 per t for baling and transportation of waste plastics.

Waste collectors claim that these prices are too low. Instances were quoted where the higher grades are sold at R200 per ton to reprocessors outside the Association. It is claimed that prices dropped considerably because of the Association's regulations. One collector estimates that prices were 80 per cent to 100 per cent higher before the Association was formed and while prices dropped over the past two years, waste collectors had to face five fuel price increases and three wage increases. This situation has had a serious effect on the economic viability of plastics waste collection. Other problems encountered in plastics waste collection as seen by collectors are :

(a) High cost of transport because plastics are a lightweight product. Eight-ton trucks are used with built-up sides 3 m high. In total, only 2 ton of plastics waste can be stacked at a time because of high volume to weight ratio of plastics waste products.

(b) End use sectors where waste plastics are available expect too high a price for the waste materials. They are not keen to co-operate in selection and storage of plastics waste for the collector. Although waste dealers supply these sources with containers for plastics waste no significant co-operation is obtained.

(c) Domestic waste is considered to be the biggest source of waste plastics. Because of economic reasons it is not feasible to collect this waste. Collectors feel that more could be done to pre-select waste and to make this available to collectors in economic quantities.

(d) In some instances use was made of school children to collect domestic waste - this was only successful in Black schools.

(e) Waste plastics reclaimed from Municipal dumps are an insignificant (one per cent to two per cent) fraction of total collections. Certain local authorities charge a collection fee which is regarded by some collectors as being excessive, with the result that the cost of obtaining waste plastics from this source is unrealistically high.

(f) Waste collectors claim that there is not much of a demand for waste plastics. This is contrary to the views of reprocessors who claimed that they would take all that they could obtain. Collectors argue that there is a big demand at give-away prices but that demand decreases as prices go up.

(g) Factory waste, which normally represents the higher qualities of waste plastics, is difficult to obtain. Most factories now have their own reprocessing facilities, and the importance of this source is declining.

It should be noted here that collection of waste material from tips is opposed by some municipalities on the grounds that it can be a dangerous practice for the collectors themselves. A black woman was recently killed at a tip at Cape Town due to heavy material being pushed over the edge of the tip by a bulldozer. Ultimately the municipality has responsibility for people on it's tips. There is also a certain health hazard for collectors due to their tendency to pick out waste components other than those which they are employed to pick out.

It is estimated that between 50 per cent and 60 per cent of all plastics waste recovered in South Africa is handled by trade collectors. The balance is obtained directly by the reprocessors or converters themselves. The major sources of waste plastics for trade collectors are as follows :

Used plastics products	± 85%
sacks bags plastic cups plastic containers bottles reels crates containers, etc	
Factory waste	± 10%
Municipal dumps	2%
Other	3%

Trade collectors pointed out that the market for HDPE has been very unstable in the past. Higher tonnages of HDPE are now available, and converters/reprocessors are looking for ways to use more HDPE in the products that are being manufactured.

Trade reprocessors

Trade reprocessors use plastics waste to produce a plastic raw material for the plastic products industry. In some cases, part of the refined plastics waste is used for the manufacture of final products, but the main objective is to resell plastics raw material in a granular form. Granulated plastics are sold at prices ranging from R500-R550 per t. It is regarded by plastic converters as a low grade material, since it's composition is not specified. There are restrictions on the range of products that can be manufactured from reprocessed waste plastics. For instance, no kitchenware or products containing foodstuffs for human consumption may be manufactured from this raw material.

Although no accurate figure could be obtained, it is estimated that reprocessors resell in the order of 40 per cent of all waste plastics recycled in South Africa. Waste plastics are either bought from waste dealers or obtained directly from the source of waste generation. Waste products account for the major share of their intake.

Reprocessors are optimistic about their future. The price of virgin materials is the main factor that will determine future demand. Expectations are that they will increase faster than those of refined waste plastics. It was pointed out that

(a) the refining process is not labour or power intensive and therefore prices will remain stable, and

(b) the energy required to convert oil to polymers is retained, resulting in a large cost saving.

Expectations are that prices for virgin materials will increase again around July this year and will reach a level of close to a R1 000 per t for HDPE. Imports will probably be resumed towards the end of the year and the local supply situation is not expected to change much before Sasol II is completed in the 1980's. Based on the above factors, a growth in turnover volume for trade reprocessors of between 15 and 20 per cent for the next five years is forecast by various spokesmen for the industry.

Waste converters

There are a large number of waste plastics converters who either buy granulated waste from trade reprocessors or buy direct from the source of waste generation.

It is estimated that approximately 15 000 t of waste plastics are recycled and used in this way. This excludes in-plant recycling of factory waste which is not considered as recycling for purposes of this report.

Waste converters who obtain their waste products direct from source, experience the same problems as trade collectors, in that very little co-operation is received from sources where plastics waste is available. They expressed the opinion that there is a need for more trade collectors and feel that this could stimulate the growth of the waste plastics industry.

No serious complaints concerning fluctuations of supply were voiced, but it was pointed out that plastics packaging materials used in the beverage industry (mainly shrink wrap) are subject to seasonal variation. Converters are of the opinion that there is a shortage of waste plastics, and ascribe this largely to the rapid reduction during the past two years of available in-plant waste.

Converters pointed out that they prefer to buy waste plastics in the original form (as a plastic bag or crate), and are not too keen on buying refined, granulated waste. This does not apply in all cases, and depends on the end product to be manufactured. The reason given is that converters are not always sure of what they are buying when waste is in a refined form.

The consensus of converters' opinion is that good market prospects for their products exist, and that the high growth rate experienced recently should continue. One or two converters are uncertain of the long term acceptability of their products due to their inferior quality when compared to products made from virgin materials, and feel that this may hamper future growth.

The size of the recycling industry and future prospects

It is estimated that 15 000 t of plastics waste, representing between 11 and 12 per cent of recyclable plastics waste is recycled. It was pointed out in the section on the consumption and application of plastics that between 125 000 and 135 000 t of plastics is used in such a way that it could be considered as a potential source for recycling.

LDPE is by far the biggest component of waste plastics recycled. A breakdown of the estimated percentages for various types of plastics wastes currently recycled is given in Table 3.

Table 3

Main types of plastics recycled

	% of total	Tonnage
LDPE	72,1	10 800
HDPE	17,2	2 600
Polypropylene	6,3	950
Polystyrene	4,4	650
	100,0	15 000

LDPE is obtained mainly as packaging material in the form of bags, sheeting, shrink wrap and other wrappings. HDPE is collected in the form of crates and rigid containers. It is estimated that more than 90 per cent of the total waste plastics intake is in the form of packaging materials. The most commonly used waste plastics products are:

- shrink wrap sheeting and other wrappings
- plastic bags, fertilizer bags, etc
- plastic sacks - shopping bags
- crates and heavy containers
- cable reels
- yoghurt cups
- milk and Bantu beer bottles
- factory waste, etc

There are various factors influencing the growth prospects of this industry, such as the acceptability of its end products, the price and availability of virgin materials, and the price and availability of waste plastics materials.

Waste reprocessors and converters are optimistic about their future. High growth rates have been achieved in the past few years and this is expected to be maintained over the medium term. A growth of 12,5 per cent per annum during the next five years is considered to be more realistic than the 15 to 20 per cent projected by some converters. If this can be achieved, the volume of waste plastics recycled will increase to about 25 000 t in 1980.

Products manufactured

A wide range of products are currently manufactured from waste plastics. Although no accurate figures could be obtained, it is estimated that the value of output of this industry is in the region of R10 to R12 million per annum. The following products are manufactured:

refuse bins

sanitary pails

portable toilets

irrigation tubes

explosives curtains

explosives packaging

coat hangers

children's play spades and buckets

plastic carpets

crates and containers

polystyrene - panels

- drawers for cabinets

- bathroom units

plastic sacks

flower pots

cable covers

agricultural and other film

The use of waste plastics in the manufacture of coffins is currently being investigated and could be a big new outlet for recycled plastics material.

Problem areas

Most of the problem areas identified by collectors and users of waste plastics were discussed in the previous sections. They are now summarized below:

Technical problems

Very few technical problems are experienced. It was mentioned that plastics waste recovered from Municipal tips is very dirty and poses some problems in the refining process. This increases the overall cost structure of recycling waste plastics.

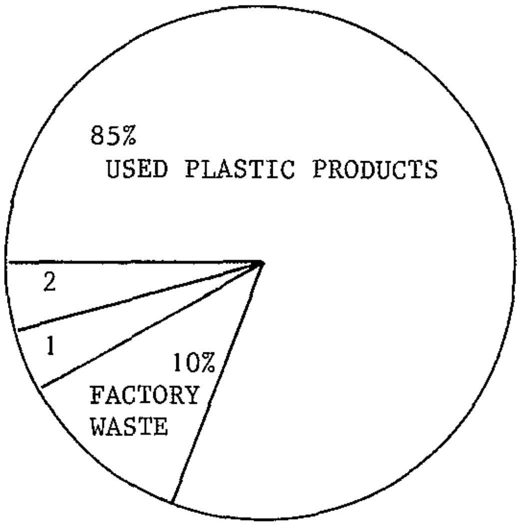
Users' problems

- Converters and reprocessors complained that there are too few waste plastics collectors and that supplies are irregular.
- Waste plastics sources are not co-operating in selecting and storing waste plastics for collection.
- Because of irregular supplies stocks have to be kept at high levels, up to 12 months stock.
- The long term future of some of their products is not secure and producers fear that some may be replaced by non-waste based products because of inferior quality.

Collectors' problems

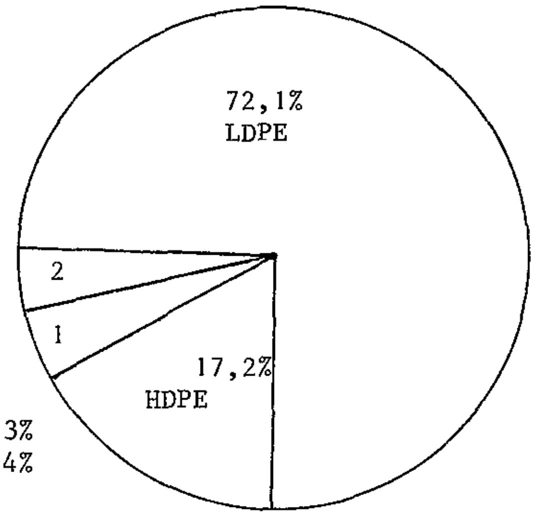
- The current price structure suggested by the Plastics Recycling Association is too low and threatens the economic viability of waste plastics collection.
- Collecting of waste plastics is in many cases done as a sideline, and collectors will concentrate on their major activities again when the economic situation improves.
- The biggest source of plastics waste (domestic waste) is still untapped. Collectors feel that something should be done to make this waste available in economic quantities.
- Local authorities are demanding too much of collectors for the right to search their dumps - this makes the collection of plastics waste from that source an uneconomical proposition.
- In order to facilitate comparison of the consumption of plastics, recycling of waste plastics, and the types of waste utilized, some of the figures given in chapters 2 and 3 are set out graphically below.

Figure 3.



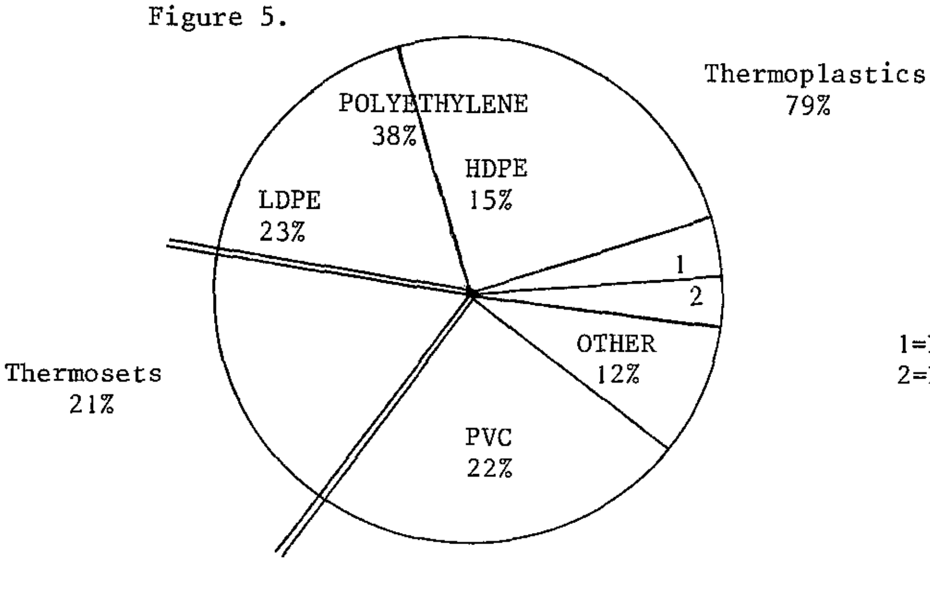
1 = OTHER, 3%
2 = MUNICIPAL DUMPS, 2%

Figure 4.



1 = POLYPROPYLENE, 6,3%
2 = POLYSTYRENE, 4,4%

Figure 5.



1=Polypropylene 3%
2=Polystyrene 3%

THE DISPOSAL OF PLASTICS WASTE

In this section, attention is given to the effect that plastics, present in waste, have on disposal methods used for mixed solid waste. Attention will be focussed on urban refuse disposal since other solid waste types, such as industrial waste, are either disposed of privately, or become part of the urban refuse.

Plastics in sanitary landfill

The presence of plastics in sanitary landfill reduces the quality of the landfill. This is due primarily to the fact that plastics, and especially light plastic containers, have a certain amount of compaction resistance and therefore create voids in the landfill, reducing its density and eventual stability. Because buried plastics are virtually non-degradeable, collapse of containers, and thereby elimination of voids does not occur with time. Plastics material in landfill does not contribute to water pollution through leachates, due to its insolubility in water. Despite the detrimental effect of plastics on landfill quality, the proportion of plastics in mixed urban refuse (3%-5%) is not high enough to cause any noticeable problems.

In practice, however, the non-degradeability of plastics is no more disadvantageous to a sanitary landfill than other non-degradeable materials such as concrete or bricks. Plastics constitute a problem in sanitary landfill operations only when large consignments or slugs are received together, and not in admixture with other urban waste. This, however, is a question of management and can be overcome reasonably easily.

Plastics in compost

If compost is used primarily as a soil stabilizer, which is the case in South Africa, the presence of small quantities of plastics provides no objective problems. Particles of plastic in compost are reflective and conspicuous, and some farmers do object to their presence. Research is being conducted overseas into methods for the separation of plastics from pulverised refuse. The only noticeable effect is a slight change in colour, and, where the plastics concentration is high, bacterial action can be retarded.

Plastics in incineration

It is as a component of incinerated waste that plastics waste has received the most derogatory comment in recent years. PVC, which releases hydrogen chloride at a temperature of 250°C, is the chief offender (Boettner 1972). In combination with water, hydrogen chloride produces hydrochloric acid, which is highly corrosive. Gas scrubbing of incineration products neutralizes the hydrogen chloride and the problem can thereby be eliminated. Research directed at the development of additives which will resolve the problem is currently being conducted. Some other plastics, such as polysulfone, polyimide, polyphenylene and polycarbonate have toxic or corrosive combustion products, but their use is so small as to make the danger negligible. Incineration is not carried out to any significant extent in South Africa. Trials in Sweden, the USA and Europe have confirmed that with the present levels of PVC in refuse, the amount of HCL generated does not present a corrosion or pollution hazard (The British Plastics Federation, 1973).

Plastics in materials recovery systems

No complete materials recovery systems are in operation in South Africa. A number of EPA demonstration projects are under way in the USA, with the object of determining their economic viability. Methods have been developed whereby mixed plastics may be isolated from other waste, and then separated into various plastics types. Due to their relatively high resale value, plastics are a welcome component of waste in materials recovery systems. Table 4 gives an indication of the prices of constituents in South Africa.

Table 4

Prices paid for waste constituents

Material type	Price (R/t)	
	Uncontaminated	Contaminated
Paper, board and rags	18	9
Glass	10	7
Ferrous metal	20	10
Non-ferrous metal	400	200
Mixed plastics	60	15
Source : Bolitho, V; Possibilities of recycling in South Africa : Choices and conflicts op cit p 6.		

Plastics in Litter

By previous definition, plastics in litter (a dispersed source) are not recyclable, and increased recycling does not affect the litter situation appreciably. Solutions to the litter problem are rather to be found in prevention, or efficient cleaning services, or both.

Conslusion

There is room for improvement in regard to the level of plastics recycling activity. Due to the fact that authorities responsible for waste disposal in South Africa generally experience very few problems resulting from the presence of plastics in waste, it is concluded that there is no need for further research directed specifically at the disposal aspect of plastics in urban waste.

OVERSEAS DEVELOPMENTS

The three overseas areas which will be considered are the European Economic Community, the USA and Japan, since these represent the major worldwide consumers of plastics.

European Economic Community (EEC)

Demand

The total demand in 1971 for plastics was approximately 11,3 x 10^6 t, and the estimated demand in 1980 is 22 - 23 x 10^6 t, of which the probable application distribution is summarised as follows (Fergusson 1973).

Table 5

Typical application breakdown (UK) by industry sector

	1971	%	1980
Packaging	25,1		30,9
Building	26,3		24,2
Electrical/Electronic (excluding consumer durables)	8,8		5,5
Consumer products	14,0		10,0
Furniture	5,7		7,2
Land transport	7,0		9,5
Agriculture	10,7		8,7
Others	2,4		4,0
	100		100

It is clear that the packaging field will grow significantly, hence a closer analysis of the nature of materials used in the packaging field is given for 1971.

Table 6

Main raw materials used in the production of packaging - UK and W Germany

	UK 1971		W Germany 1972	
	t x 10^6	%	5 x 10^6	%
Paper products	3,5	48	3,8	41,5
Metal	1,5	21	1,1	12,0
Glass	1,5	21	2,6	28,0
Plastics	0,4	6	0,8	8,5
Others (wood and natural fibres)	0,3	4	0,9	10,0

A large proportion of packaging materials ends up as waste (domestic, industrial, construction) and requires disposal. Plastics used in the building, electrical, furniture and agricultural sectors to a large extent are planned to have a finite life time varying from say six months to 50 years, hence constitute a less serious waste disposal problem.

The level of plastics waste compared with the consumption as given in Table 7 illustrates the magnitude of the problem.

Table 7

Relationship between plastics production, plastics consumption and solid and plastic waste

Country	Production, 1968	10^6 t 1972	Consumption, 1968	10^6 t 1972	Solid Waste 10^6 t 1970	Plastics Waste 10^6 t 1970	Percentage of plastics waste 1970 %
W Germany	3,3	5,4	2,40	4,2	17,5	0,65	3,7
UK	1,2	1,65	1,06	1,45	21,7	0,325	1,5
France	1,0	2,03	1,06	2,10	11,0	-	3,3
Italy	1,43	2,0	1,05	1,73	-	-	-
Belgium	0,25	2,0	1,05	1,73	-	-	-
Netherlands	0,54	1,08	0,24	0,38	-	-	-
Sweden	0,28	(1970)	-	-	3,2	0.06	3
Switzerland	0,07	(1970)	-	-	2,1	0,063	3

Disposal

The EEC countries differ only slightly in the manner in which disposal of waste is treated. An analysis of the methods used in France and the UK is given in Table 8.

Table 8

Employment of waste disposal methods in France and the UK

	France	UK	
	1972 (%)	1972 (%)	1980 est (%)
Incineration	30	10	20
Composting	13	-	-
Landfill	57	90	80
Total	100	100	100

Conservation

Reprocessing received a definite boost following the dramatic increase of polymer prices in the 1973/1974 period. The oil crisis encouraged capital investment for recycling plants as well as removing plastics from the realm of cheap, readily disposable materials.

United States of America

The 1970 production figure of 8,82 x 10^6 t illustrates America's position as the world's largest producer of plastics materials.

Demand

The consumption of plastics in 1970 was estimated at 7,5 x 10^6 t (Tebbatt 1973) and is expected to rise to 27,2 x 10^6 t by 1980 (Plastics World 1974). The volume of plastics waste in 1970 is given as 3,9 x 10^6 t, which constitutes two per cent of the total 190 x 10^6 t of solid wastes. It is projected that by 1990 the plastics content will be 3,5 per cent of a total solid wastes volume of 270-320 million t (Midwest Research Institute 1973).

Disposal

The pattern of disposal in 1966 was similar to that of the UK, incineration being nine per cent, composting one per cent and landfill 90 per cent (Europlastics 1973). This pattern can be expected to change, with incineration playing a larger role because of the ever increasing transportation costs and scarcity of ground, and the concern shown in recent years for fossil fuel conservation. Landfill is expected to decrease correspondingly.

Conservation

The USA behaviour pattern has been one of "use and throw away" in the past. This is changing rapidly as is reflected both in research papers published on the role of plastics in resource recovery (Midwest Research Institute 1973) and, more significantly, legislation against one-way packaging.

Examples of legislation are typified by New York City laws passed in June 1971, which levied a 2c tax on all non-food plastic containers. The law was subsequently repealed in 1972, following a law suit by representatives of the plastics industry.

Comparison with alternative materials

The Society of the Plastics Industries commissioned the Midwest Research Institute to undertake a resource and environmental profile analysis of plastics and competitive materials (Midwest Research Institute 1974). This highly scientific and detailed study has considered the use of materials in terms of a total environmental impact index. This new concept considers the effects of raw materials, energy requirement, process water, industrial solid wastes, atmospheric emissions, waterborne wastes and finally, post consumer wastes.

The results of computer-based analysis show that plastics, in all the cases considered, have a less detrimental impact on the environment than glass, paper, aluminium and steel.

The implications of such a study for the plastics industy are clearly that a method has now been developed with which any given packaging application can be analysed to produce an objective picture of the total environmental impact of a product, rather than the often emotional reactions expressed toward unsightly litter.

Japan

Plastics utilization in Japan presents a sharp contrast to the situation of the EEC and the USA. This is so because Japan has a relatively small land area with a high population density, combined with high per capita consumption of plastics.

As a result of its unique circumstances, the Japanese authorities have passed aggressive legislation to control the use of plastics materials and their subsequent disposal.

Demand

The growth in this industry has been dramatic in the last 20 years. The current (1975) production of all plastics amounts to 6,69 x 10^6 t (Japan Chemical Week 1975). A significant proportion is exported, but for a population of 100 million, this figure, if similar to consumption, represents a per capita consumption of approximately 60 kg.

Disposal

The disposal pattern in Japan is unique, as can be seen by the estimates for the methods of disposal planned for 1976.

Table 9

Analysis of disposal methods in use in Japan in 1976 (estimated)

Method	Amount, 10^6 t	Percentage, %
Simple reclamation	0,15	6
Complex reclamation	0,263	10
Thermal decomposition	0,11	5
Incineration	1,612	61
Landfill	0,454	18
Total	2,589	100

The source of this plastic waste helps to throw light on the application fields and their respective contributions as seen in Table 10.

Table 10

Plastics waste by end user in Japan for 1971, 1974 and 1975
(Plastics Industry News 1974)

End user	Plastics Waste produced, 10^5 t			Percentage, % for 1976
	1971	1974	1976	
Polymer manufacturers	1,0	1,22	1,41	5,4
Moulders	1,28	1,68	2,00	7,6
Agriculture	0,21	0,30	0,33	1,3
Production	1,07	1,55	1,93	7,4
Large Containers	0,21	0,79	1,13	4,3
Disposable packaging	1,30	1,89	2,34	9,0
General house	7,3	10,59	13,14	50,0
Others	1,56	2,07	2,58	10,0
Total Waste	14,58	20,97	25,89	100,0

The proportion of plastics in municipal waste was the subject of heated and often emotional speculation in the early 1970's, but the following Table 11 illustrates that Japan has had only slightly higher levels than those experienced in W Germany, for example. Levels as high as 10-15 per cent were quoted, seemingly without foundation. The level of PVC has been singled out for special attention, presumably because of the problem of cleaning the combustion gases, which contain HCl.

Table 11

Proportion of plastics in overall municipal refuse for 1969 - 1975 in Japan (Japan Plastics 1973)

	1969	1970	1971	1972	1973	1974	1975
TOTAL refuse, 10^6 t	3,89	4,26	4,64	5,05	5,48	5,91	6,34
Total Plastics waste, 10^6 t	0,132	0,153	0,177	0,215	0,234	0,266	0,290
Plastics content, %	3,4	3,6	3,8	4,3	4,3	4,5	4,6
PVC content, %	0,42	0,54	0,57	0,64	0,61	0,67	0,73

Conservation

Japan has been a leader in the field of reclamation of plastics wastes. The literature makes numerous references to applications developed specifically to utilize the physical properties obtainable with mixtures of waste plastics materials and various fillers. Typical examples are:

1. Conversion of thermoplastics to fuel oil.
2. Fence poles replacing wooden fence poles for ranches.
3. Drain pipe from scrap PVC.
4. Composite materials with sawdust for injection moulding.
5. Shoe soles and farm water tanks are made from reclaimed PVC sheeting.

In an attempt to help with reclamation of plastics, a pre-separation experiment at Funabashi (population 332 000) was started in 1971 on a pilot scale. Now over 30 000 households separate their domestic refuse and collection of the various categories of waste in individual plastic bags has proved very successful.

Appendix A

Apparent Consumption of Plastics in South Africa (1974)

		Years before disposal ('000t)			
		0 - 1	0 - 5	5 +	Total consumption
Thermoplastics					
Polyethylene - LD	Films, Coatings	68			
	Mouldings, Bottles	10	3		
	Cable			12	
	Pipe		4	4	101
Polyethylene - HD	Closures, Containers (in plant)	16			
	Film	10			
	Mouldings		16	6	
	Pipe, tapes, twine	2	12	5	67
Polypropylene		5	5	4	14
Polystyrene, ABS/SAN	Trays, Packaging	5			
	Kitchenware, Fittings, Furniture		5	4	14
PVC	Sheet & Film	2	9	10	
	Mouldings: bottles, footwear, records, misc.	8	8	1	
	Film, Cable & wire, Flex extrusions, Rigid pipe, sheet, Belting	2	5	50	95
Acrylics				2,7	3
Polyethylene terephthalate			19	1	20
Polyamide			7	7	14
Other			7,2	7	14
		128	100	114	342
Thermosets					
Phenolics	Shell moulding	1			
	Fittings			4	
	Wood	0,4		7	12
Aminoplasts	Wood, Chipboard	2		34	36
Polyester				8,8	9
Epoxies				2	2
Polyurathanes			2	17,5	19
Others			3	12,8	16
		3	5	86	94

Appendix B

Generation of waste from the "Five" thermoplastics

	Plastics Consumption ('000t)	Waste disposal before 1 yr ('000t)	Waste disposal 0-5 years after consumption					Waste disposal after 5 yrs ('000t)	Total waste generated ('000t)	% disposal before 5 yrs	% disposed before 1 yr	Recyclable waste ('000t)
			0-1 ('000t)	1-2 ('000t)	2-3 ('000t)	3-4 ('000t)	4-5 ('000t)					
1968	87	38	4	4	3	3	2	14	68	79	62	48
1969	104	46	5	4	4	3	2	16	80	80	64	57
1970	126	55	6	5	4	4	2	17	93	82	66	68
1971	152	67	7	6	5	4	3	18	110	84	67	83
1972	188	83	8	7	6	5	4	20	133	85	68	101
1973	234	103	11	9	7	6	4	22	162	86	70	127
1974	294	129	13	11	9	7	5	24	198	88	72	160
1975	230	101	10	14	11	9	7	29	181	84	61	131
1976	232	102	10	11	14	11	8	34	181	81	62	130
1977	263	104	12	11	11	14	10	42	204	79	57	133
1978	294	129	12	12	11	11	13	50	238	79	59	159
1979	333	147	15	13	12	11	10	62	270	77	60	181
1980	373	164	18	16	13	12	10	77	310	75	59	205

NOTES

1. Historical figures for PVC and LDPE were obtained from the Financial Mail of April 11, 1974, and 1974 proportions used to arrive at total figures for the five thermoplastics.

2. A constant relationship between times before disposal is assumed, being 45% 0-1 years; 23% 0-5 years; 33% 5+ years.

3. Figures used are for apparent consumption, and do not take stock-holding policy changes into account.

4. The distribution of waste disposed of between 0 and 5 years after consumption is assumed to be straight line i.e. equal amounts are disposed of after each year.

5. Waste disposed of five years and more after consumption is assumed to become waste on average, seven years after consumption.

6. Recyclable waste is all waste discarded 0 to 2 years after consumption plus half of that discarded after three years.

REFERENCES

Boettner, E A and G L Ball 1972. Combustion products of plastics and their contribution to incineration problems. Volume 68. New York, 1972. 13 pp.

Bolitho, V 1975. Possibilities of recycling in South Africa : choices and conflicts. Paper presented at the Symposium on Recycling of Waste Materials, Sandton, 16th October 1975, 6 pp. Typescript.

Europlastics Monthly 1973. Focus 2; Recycling and recovery of plastics. London. Volume 46, no 3. 66-76.

Fergusson, W C 1973. Plastics, their contribution to society and considerations of their disposal. British Plastics Federation, 1973.

Henstock, M 1975. Materials recovery and recycling in the USA. Resources policy, March 1975. IPC Science and Technology Press Ltd, Guildford. 172 pp.

Japan Chemical Week 1975. Pamphlet no 66 (520) (058).

Japan Plastics 1973. 7th April 1973.

Midwest Research Institute 1974. MRI project 3714-D. November 1974.

Midwest Research Institute 1973. Resource Recovery : The state of technology. Report prepared for the council on Environmental Quality by the Midwest Research Institute, Kansas City, Missouri 1973.

Midwest Research Institute 1973. The role of plastics in resource recovery. May 1973.

Plastics Industry News 1974. Japan. 1974.

Plastics World 1974. Cahners Publishing Company Incorporated, Boston. Volume 32, no 2.

Tebbatt, T E 1973. Plastics in Western Europe, prospects for the seventies. Europlastics Monthly, London Volume 46, no 6, 158-162.

The British Plastics Federation 1973. Plastics and the environment-plastics, their contribution to society and considerations of their disposal. London. 1973.