UWEP
Urban Waste Expertise Programme

Plastic Recycling in Bangalore - India

Case-Study Report
Plastic Recycling

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PREFACE

This study has been done in the framework of UWEP, the Urban Waste Expertise Programme, a six-year programme - 1995-2001 - of research and project execution in the field of urban waste management in the south. UWEP aims at:

- generating knowledge on community and small and micro enterprise involvement in waste management
- developing and mobilizing south expertise on urban waste issues
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The Urban Waste Expertise Programme covers a range of topics related to waste management in the context of the urban environment in the south - solid waste collection and transfer, waste minimization, recycling of various waste fractions, resource recovery and liquid waste treatment.

Waste management and its various stakeholders now form a rapidly growing area of interest. The role played by small and microenterprises and communities, however, is still much neglected. UWEP aims to generate, analyse, document and customize the information that is gathered during research and pilot projects, in order to enhance the expertise of the UWEP target groups, ultimately aiming at an improved integrated sustainable waste management system. This will in the long run lead to an improved environment, create more employment and offer improved urban services for everyone.

One of the UWEP research topics was plastic recycling and the possibilities of responsible re-use by involving small enterprises. This report, *"Plastic Recycling in Bangalore - India ",* reflects the results of a case-study research done by Esha Shah and Rajaram, commissioned by WASTE, the executing agency of the UWEP programme. Similar researches on the topic of plastic recycling were undertaken in Chile, Colombia and Peru. By publishing these casestudy reports, we explicitly aim at divulging the data gathered during the researches. UWEP sees this report as one of the ways of focusing attention on small and microenterprises, community involvement and their invaluable role in urban waste management.

Hopefully this publication helps you to form a picture of the role the various stakeholders play in urban waste management. More information and an overview of the other UWEP reports and books can be obtained from WASTE.

The *UWEP Case-study Report* series are published informally by WASTE. In order that the information contained in them can be presented with the least possible delay, the typescript has not been prepared in accordance with the procedures normally adhered to. WASTE accepts no responsibility for errors.

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CHAPTER 1 INTRODUCTION

The objective of the current research is to analyse practices followed by small scale plastic recovery and recycling units in Bangalore, India. It attempts to inquire into how plastic recycling units functions with relation to technical, environmental/health and financial/economic aspects. It also intends to identify possible sources of occupational health hazards due to recycling. It finally discusses relevant national and global policy issues and suggests possible ways for improvement.

Chapter two outlines plastic industry and plastic recycling industry in India with relevant facts and figures. Processes, practices and financial analysis of plastic recovery and plastic recycling units are described in chapter three and four respectively. Chapter four describes possible sources of occupational health hazards and the final chapter discusses issues and suggestions.

1.1 Research Methodology

1.1.1 Plastic Recycling Units

Processes and practices followed and financial analysis of plastic recovery and recycling units may be considered a relatively difficult exercise. We have adopted following methodology to access and cross check the data.

- In the first round, we contacted the president of Karnataka Small Scale Plastic Manufacturers Association to get first hand idea of plastic recycling. Two volumes *(A Guide to Plastics)* published by the association gave further information including a separate list of reprocessing units in Bangalore. This provided the broad understanding of the nature of the plastic recycling industry in Bangalore.
- The selection of units for the financial analysis posed a serious problem. Although we wanted a representative sample, the willingness of the entrepreneur to provide information became major criteria. Besides, it was clear that without the introduction by the inside person it will be difficult. The units were chosen with the help of a plastic recycling industrialist.
- The data of each unit were first collected with the help of the informer. Each unit was then visited for few times. Cross checking was done at various levels
  a) Prices of raw material and final products were checked in the market
  b) The quotation received from a machine manufacturing unit gave idea about market prices of the machinery. In addition, a local small machine manufacturing workshop located in Nayandahalli was contacted, under the guise of establishing a recycling unit, to understand what it would mean to have second hand machinery.
  c) Rent and land value were checked for the area.
  d) d) Pigment and additive suppliers were contacted not only to procure quotation but also to understand the type, quantity and nature of the pigments and additives used for recycling. After a proper scrutiny data of two units were discarded.

1.1.2 Middle Dealers and Wholesalers

Given the nature of this part of the recycling industry, a person with long working experience of working with waste pickers and middle dealers was approached for research assistance. The friendly relations made by the research assistant with Middle dealers during his previous job with one of the NGOs made it possible to access the information. He not only obtained the data but also cross checked with his own understanding of interviewees' dealings through years. Along with him, place of the Middle dealer was visited a number of times. Besides, the data was further cross checked by interviewing the waste pickers supplying at Middle dealers' places. Out of a total 7 Middle dealers contacted, only 4 were found appropriate and hence presented here. The Middle dealers contacted provided further linkages to the wholesalers. A Middle dealer introduced us to a wholesaler who in turn introduced us to another wholesaler. All this cosseted number of visits and lots of talking, often completely irrelevant matter. There was no way to cross check the wholesalers data except by taking opinion of the Middle dealer supplying at his place. Only two wholesalers agreed to provide financial data within the time limit of this research.

Clarification

While trying to understand the logic of sorting, packing and selling the waste from Middle dealer's point of view we came across a system, though has its own order, not very easy to grasp by a researcher during the limited time of exposure. There were many practical problems (other than the Middle dealers' apparent reluctance to talk about business) encountered when we tried to fit their logic into the framework of this research. Following are some of the issues.

- The practice of sorting vary widely from one person to another. Although apparently waste is sorted according to type and quality, we felt that sorting is done ultimately, according to the likely price a category of waste may fetch. For instance, a sorting category known as 'article' comprises combs, toothpaste cover and acrylic sheet with various other components. Though seemingly unrelated in terms of type and quality these various components are packed in to a sack and sold at one price. Moreover, price is negotiated depending upon the number of acrylic sheets in the sack and it varies any where between Rs. 11 /kg to Rs. 35 /kg. This is also true for other categories of waste. The final price depends upon the negotiation capacity of Middle dealer which in turn depends on his experience, knowledge and relation with other actors in the business. Similarly, what a Middle dealer pays to a waste picker also varies depending upon the period of association with a waste picker, regularity of waste supply and quantity.
- It is not very clear what exactly falls into a 'category' of waste. *Pugga* is one such category. What we saw as *Pugga* at one Middle dealer's place differed drastically from what we saw at another place. However, eventually we felt that the norms followed in waste collection, sorting and packing are very informal and contextual. They depend on the tradition, the demand from the Wholesaler, type of waste received and, most importantly, the capacity of the middle dealer to negotiate the price.

- A major problem was encountered when we tried to understand the quantities of waste collected and sold. In the absence of any written records, a Middle dealer depends upon his memory, which may not capture seasonal fluctuation.

  Besides, the logic of quantity of waste purchased and sold also do not tally. The quantity of waste purchased is expressed as kgs.. per day, whereas the quantity sold is expressed in kgs.. per week. The data was provided by the most experienced person in the shop (in majority of the cases the proprietor himself) even then the data on quantities in different contexts was differently told. This may have to do with the highly uncertain field of waste collection and trade. It varies widely from day to day, leave apart the seasonal variation. Given the informality of the entire business, proper documentation is least expected. Besides, quantities were expressed in a range of plus or minus 20 kgs.. per day. This can create a discrepancy of half a tone when counted on monthly basis. Further, it does not match with the same category of waste sold.

  After juggling with seemingly incomprehensive data encountered in the first round we decided to follow some other method. Hence, we combined three ways to make our own judgment

  - we took the quantity told by the middle dealer as base figure and modified it depending upon the number of waste pickers and *Kabadiwalas* selling at his place.
  - the quantities of waste sold was also modified after talking to a number of waste pickers. The figures were cross checked with the help of other knowledgeable people in the business.

Hence, we clarify that the idea here is to give broad understanding of a Dealer's practice. This invariably imposes several limitations on the quality of financial analysis.

CHAPTER 2 PLASTIC INDUSTRY IN INDIA

The estimated per capita demand of plastics in India is 0.800 Kgs. which is one of the lowest in Asia. The projected demand in 2000 A.D. is 2.16 Kgs. per capita (KSSPMA, 1992). A boom in the consumption of plastic is experienced with the economic liberalisation since 1991. Plastic consumption in India has more than doubled from 0.85 million tones during 1990-91 to 1.79 million tones during 1995-96. Demand for commodity plastics is growing at the rate of 15 % per year. As per the survey conducted by the All India Plastic Manufacturers Association the total capacity to produce PE, PVC, PP and PS was 1.39 million MT and demand was 1.55 million MT in 1995 which has increased to 1.8-1.9 million MT for 1996-97 (KSSPMA,1992). This is concentrated in three major sectors according to the Plast India figures: infrastructure (power, telecommunications, roads, bridges and construction) which is 30 % of the total, packaging is 25 % of the total and 24 % for agriculture and water (Nanavaty, 1997). Based on the end use consumption pattern the plastic waste generated has more than doubled to 0.8 million tones during 1995-96. It is estimated that at a macro level 50 % of the quantity of virgin raw material consumed reaches municipal waste stream annually. Although on weight basis the level of plastics waste in municipal waste stream is only 3 % to 4 %, they occupy 25 to 30% of the volume. It is projected that the plastic waste generation will reach the level of 1.6 million tones annually by year 2001-02 (Sundaresan, 1996).

2.1 Plastic Recycling Industry in India

2.1.1 History

It is difficult to trace back when exactly the recycling would have started in India. In 1950s and 1960s, with the growth of large scale petrochemical industries, the small scale processing units were established in Western Indian states of Gujarat and Rajasthan. On the basis of informal interaction with various people in the field of recycling it may be suggested that recycling of the waste generated from the manufacturing and processing units would have been the first step. The machinery required for the reprocessing is technically similar to the processing machinery.

However, the widespread recycling of plastic waste, both from industrial and municipal origin might have been started in late 1970s and early 1980s. This was the time when the liberalisation attitude was set in with Janatha Government in power in 1977. The Government explicitly recognised the small scale manufacturing sector through exemptions from excise duties and other taxes, reduced paper work and adhoc licensing scheme started for tiny industries. And with the New Economic policy started in 1984 by the Congress Government industrialisation was promoted which gave enormous boost to consumer market. Simultaneously the upper limit for small scale industries[1] was increased calling for corresponding boost in the small scale

[1] Currently Small Scale Industries in Indian context are characterised by having 5-25 employees and having less than RS. 3,00.00.000 of investment.

industries. Plastic processing and reprocessing industries can be considered as one among many such newly established small scale units at that time.

The wide spread recycling of the plastic waste is generally associated with the commencement of milk packing in plastic sachets. It also corresponds with the time when plastic carry bags were also started to be used. The substantial amount of plastic waste started reaching streets approximately the same time. However, it is felt that the waste from the newly proliferated processing units might have made recycling economically viable. Recycling of municipal/ post consumer waste may be an offshoot of such industries mainly meant to recycle industrial waste. It seems that recycling units were first established in Gujarat, Rajasthan and some parts of West Bengal which were further spread to other parts of India.

2.1.2 The Spread

There is no accurate data available on nature and number of plastic recycling units in India although various estimates are available. The current plastic recycling rate is estimated as 60% by Plast India Foundation (KSSPMA, 1992). But the discussions with knowledgeable persons reveal it to be anywhere between 80% to 93%. One estimate is that about 20,000 micro enterprises are engaged in reprocessing and recovery of plastic waste in addition to 180,000 of various sorting and washing units, 60% of which are unregistered (Harriman Chemsult, 1996). Delhi alone has estimated 53,400 units and Delhi and Bombay together process over 50% of India's waste plastics. There is heavy concentration of recycling units reported in Gujarat and Goa, which, as a whole, account for 40%. As per other estimates there are about 18,000 recycling units spread all over the country, with about 2500 palletizing units with an average output of 350 MT/ year and an over all output of over 875 kTA (Nanavaty, 1997).

India nevertheless has some of the world's largest plastic waste markets. Notable among them are: Jawalapuri in Delhi for PVC, Nand Nagari in New Delhi where trading level reaches 1000 MT/day, Dharavi in Bombay and Jolly Mohalla in Bangalore. Figure 1 shows the recycling centers in India and Figure 2 schematically represents the region wise distribution of recycling industry in India (Nanavaty, 1997).

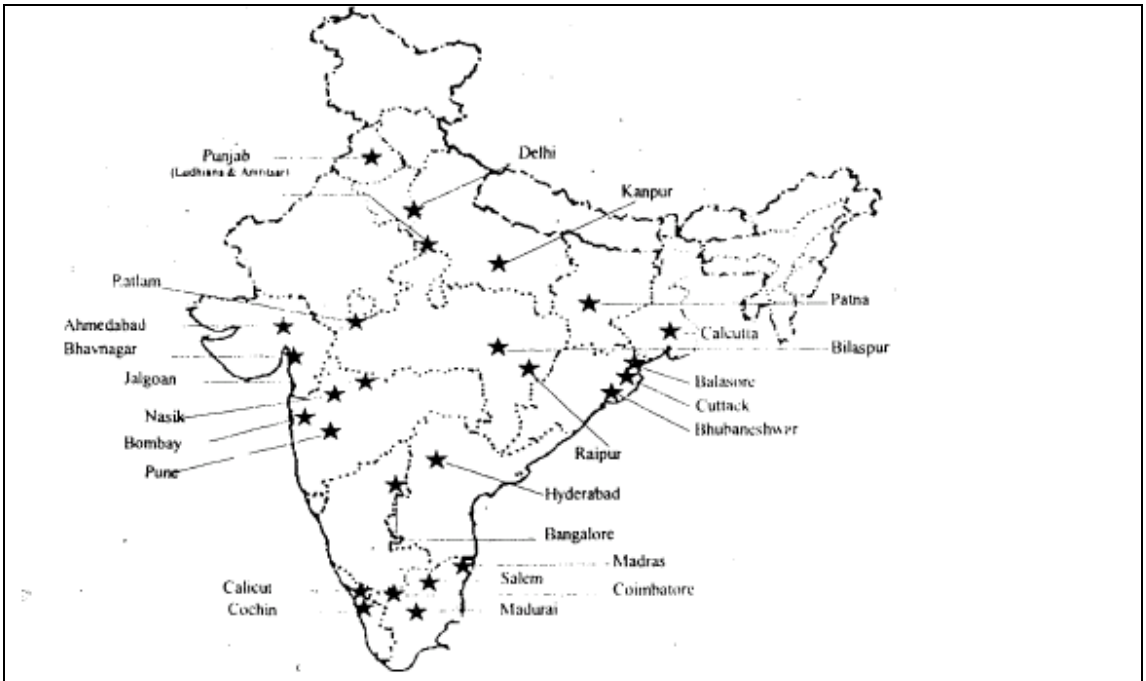

Figure 1 Recycling Centres in India

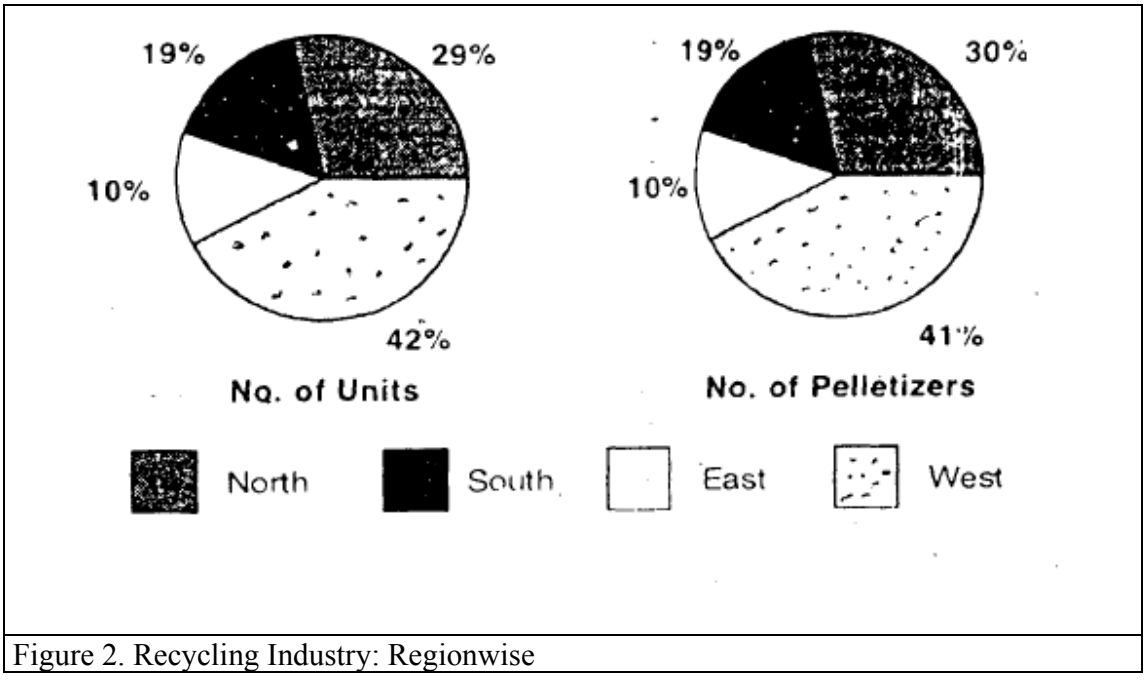

Figure 2. Recycling Industry: Regionwise

Table 1. Reprocessing in Recycling Industry: Region wise and Polymer wise in kTA

Region	PVC	HDPE	LD/LLD/HM	PP	Other	Total
West	60	113	78	65	12	328
North	135	45	38	35	14	267
South	53	41	30	29	09	162
East	34	29	04	20	04	91
Total	282	228	150	149	39	848

Source: Nanavaty, 1997.

Table 2. Region wise and Polymer wise Turnover of Recycling Industry at Pelletisation stage in Rs. Crore (1 crore = 10 million)

Region	PVC	HDPE	LD/LLD	PP	Others	Total
West	156	383	360	225	30	1154
East	75	86	12	70	9	252
North	338	158	125	126	36	783
South	111	139	108	89	23	470
Total	680	766	605	510	98	2659

Source: Nanavaty, 1997.

Each region is also specialized in one type of plastic, viz. North: PVC; South: HDPE; West: all types but more emphasis on LDPE and LLDPE; East: PP. It was suggested that one million tone of waste plastic would have been recycled or otherwise reused in 1996 - including 40% of 1995 consumption of virgin plastic and 30 % of pre 1995 production which had been reprocessed before.

The number of people engaged in recycling sector is unknown but vast. Some figures suggest that 750,000 people are employed including 86,000 rag pickers specialized in plastics (Harriman Chemsult, 1996). On an average 15 persons are required to process 240 MT/annum. Using this norm it is estimated that more than 54,000 people are employed in processing alone.

2.2 Recycling Industry in Bangalore

2.2.1 Overview

As per an estimate, Bangalore has around 300 reprocessing units with main thrust on recycling of all polyolefins and PVC although PVC recycling units are only 7 to 10. 70 % to 80 % of the collected, post-consumer waste is exported to Delhi, Bombay and Gujarat for reprocessing.

Jolly Maholla is the center for the purchase of scrap material whereas the reprocessing units are spread all over Bangalore with more concentration in Nayandahalli and New Timber Market on Mysore Road. In Nayandahalli itself around 100 pelletisation and product manufacturing units are located.

2.2.2 Amount of Plastic Waste Recycled

According to a study, 25,000 and odd number of waste pickers or *chapparwalas* as known in the local language, recover 15 % of the refuse, of which 4.08 % is estimated as plastic. On an average, a waste picker picks 8 kgs. of plastic waste and works for 17 days a month. That accounts to 136 kgs. of plastic waste picked by a waste picker in a month. If this is averaged out to 30 days of picking in a month, per day 25,000 waste pickers can collect 136 tons of plastic waste.

In addition there are estimated 3000-4000 itinerant waste buyers in Bangalore and if they collect average 10 kgs of plastic waste per day for 25 days of a month, 250 kgs of plastic waste is collected by a itinerant waste buyer in a month. If it is averaged out to 30 days of collection in a month an IWB collects 8 kgs per day of plastic waste. This amounts to total 28 tons of plastic waste collected by all itinerant waste buyers in Bangalore. If 80% of total 164 tons of plastic waste traded is exported out of Bangalore, remaining 20% i.e. 32.8 tons per day of post-consumer plastic waste is circulated in Bangalore. Assuming 250 kgs per day of recycling capacity of a unit and estimated 300 such units in Bangalore 75 tons of plastic waste is recycled everyday. Of which 32.8 (43%) tons is post consumer waste and rest is acquired through industrial sources.

2.2.3 Nature of Plastic Recycling Units

Most of the reprocessing units are operated as a micro enterprise, in an informal way. There is no clear data regarding the ethnic composition of the work force. However, it is observed that the waste pickers generally belong to the state of Tamilnadu whereas the business of scrap sorting and marketing is dominated by Muslims. Marwadis and Gujaratis, migrated from western part of India, are predominantly owners of reprocessing units. Nearly 90% of the units located in Nayandahalli are said to be owned by Marwadis with close caste and kin relationships. Majority of the male laborers employed in reprocessing units belong to Hindi speaking states of Uttar Pradesh, Bihar, Rajasthan, Gujarat and Orissa. Local laborers were evidently less compared to migrant workers. Local Women are employed mainly for cleaning, sorting and washing of raw material. They are generally not employed to work on the machine.

The reprocessing units are clustered in a similar pattern as small scale textile units are clustered in Gujarat and tannery units in parts of Tamilnadu. Although an individual unit is operated and managed in small scale, the units are located side by side in a series and are identical in terms of technology, processing methods, type and variety of raw material used and final products manufactured. The "mysteries" of trade become no mysteries and nothing is "business secret" in such an environment.

The final product of the units, be it pellets or consumer items, is generally produced only on order basis. Majority of the units even purchase the scrap only after receiving the order for either pellets or product with specifications. Depending upon the order specifications in terms of type, desired strength, purpose, color and shape the nearest suitable type of scrap is either purchased or sorted from the mixed waste in-house. Evidently each unit is specialized in specific type/types of waste and both purchase of scrap and sale of final product take place through contacts which are developed through years of experience in the business. Some of the units also accept job work wherein the scrap is purchased and sent for processing to the recycling unit by a concerned party. In such case the task for the recycling unit is to provide labor, service and machinery and flat rate per kg of plastic recycled is charged.

Since the industry operates on demand basis, the proximity of the market is very essential. In other words the ability to respond quickly to the market needs seems to be the key factor for survival of this industry. This could explain why the scrap, rather than the pellets or products is exported to Northern and Western parts of India.

2.2.4 Types of Plastic Waste

The reprocessor purchases plastic scrap according to various grades. The following is an account of approximate distinction (Leidner, 1981):

Grade A: This waste is produced during plastic manufacturing and compounding. Generally, this material is mixed, reformulated and sold. This grade retains 95% of the original properties. Approximately 40% of this waste is used within the plastic manufacturing and rest is sold to make pellets. In the unit where it is generated, often a closed loop is used where the scrap never leaves the line on which it is generated. It is also known as uncontaminated single resin waste. Evidently this grade of waste is not recycled in Bangalore.

Grade B: This is generated during fabrications and conversions operations. If kept separate and clean it is usually recycled by regrinding and remixing with virgin material. It retains 75 to 80% of the original properties.

Grade C: is comprised of post-consumer articles which are either collected directly from the households, corporation bins or from the refuse dumps. Properties depend on the level of contamination, sorting and washing.

Grade D: is the lowest grade material which is inferior quality road waste, aggregate of plastic of unknown sources or inferior quality due to defects.

Wastes Produced During Fabrication

This category includes mainly machine waste generated during both processing and reprocessing plastic. Generally, in the next cycle itself they are ground and processed within the processing unit or sold to recycling unit.

- ⇨ Extrusion produces waste from equipment start up and from trimming and cutting of the final product.
- ⇨ Injection molding produces wastes from runners and sprues in addition to machine setup and purging.
- ⇨ In blow molding waste originates from pinch off.

In addition to these types of plastics fairly clean varieties of plastic waste is generated from other industrial or agricultural sectors as well. Discarded Electric conduits are one such source. Other sources include pipes used for irrigation and water conveyance or automobile waste generated in the garages. These varieties of the waste are collected from the source of generation itself and hence remain relatively clean.

Any plastic looses, once recycled for the first time, 10-15% of its original properties if additives are not mixed. A second recycling would further decrease the quality by 30-40%. Hence, the final product is manufactured with a combination of grades or in combination with virgin plastic. The blend is decided on the basis of the desired quality of the final product.

The manufacturers seem to have a tendency to add some amount of recycled plastic even in the product supposed to be made of virgin plastic. This is possible because most of the plastic processing units are also small scale, micro enterprises and the difference in terms of machinery and expertise used for processing or reprocessing of plastic items is marginal.

2.2.5 Types of Reprocessing Units

There are four types of reprocessing units based on the final product:

- ⇨ Pellet making units: These units make pellets on the basis of order. They also rent the unit, labor and machinery for job work.
- ⇨ Pellet-cum-Product making Units: These units produce pellets or products and purchase and reprocess the scrap on the basis of the order for the final product.
- ⇨ Recycled Product making Units: These units purchase recycled pellets and make products out of reprocessed pellets only.
- ⇨ Product making Units: These units make products of either virgin plastic, blend or reprocessed plastic.

In Bangalore mainly polyolefins [which include High Density Polyethylene (HDPE), Linear Low Density Polyethylene (LLDPE), Low Density Polyethylene (LDPE), High Molecular Weight Polyethylene (HMPE), and Polypropylene (PP)] and Poly Vinyl Chloride (PVC) are

reprocessed. Part of the polyolefins, PVC in addition to Polystyrene and PET are exported to other parts of India.

Table 3. Application of Recycled Plastics

Type	Method	Application
HDPE/LLDPE/ LDPE/HMPE	Injection Molding and Blow Molding or Calendaring	*Kodams*, Bottles, Toys, flower Pots, Traffic Cones, Buckets, Tumblers, Household Items, Sacks, Agriculture Drainage Pipes, Bags, Sheets
LDPE	Calendaring	Garbage bags, grocery Bags, Sheets, Carry Bags
PP	Injection Molding or Blow Molding after controlled degradation	Buckets, Kodams, Household Items, Suitcases,
PVC	Injection Molding, Calendaring	Electric Conduits, Drainage Pipes, Irrigation Pipes, Bottles, Footwear, Cables, Medicine Covers, Rigid Pipes

2.3 Associations/Organisations Dealing with Plastics

The Department of Chemicals and Petrochemicals in the Ministry of Chemicals and Fertilizers of the Government of India is the nodal agency for petrochemicals including plastics. On producers side, there are two prominent associations of polymer producers, viz., Chemicals and Petrochemicals Manufacturers Associations and PVC Manufacturers Association. There are various national and regional organisations of plastic processing and conversion industries. Significant among them at the national level are: All India Plastic Manufacturers Association, Organisations of Plastic Processors of India, Plast India Foundation, All India Federation of Plastics Industries and Indian Plastics Federation, The Plastics Woven Sacks Manufacturers Association and All India Flat Tape Manufacturers Association. Institutions like Central Institute of Plastics Engineering and Technology (CIPET) and Indian Plastics Institute play a catalytic role for human power development and technology feedback. Plastic recyclers are organised into Waste Dealers Association and All India Plastic Waste Recycling Industries Association (TPMA, 1995).

2.4 Recycling Technologies

There are mainly three approaches to recycling: mechanical recycling, mixed waste recycling and feed stock recycling. For all practical purposes, plastic waste is recycled by mechanical recycling in India. This method needs unmixed waste material in economically viable quantities. Mechanical recycling undergoes four typical stages: sorting, size reduction, washing, separation

at chop level and melt processing. Mechanical recycling lines have been developed for nearly all major thermoplastics.

Mixed waste processing involves use of coupling agent. This technology is not widely used as plastic waste is sorted and used as single material for mechanical processing. In the process of feed stock recycling the macromolecular structure is broken down to basic monomers/ chemical and this is subsequently used for the manufacture of plastics. In India this technique is restricted to materials like PET and Polyamide.

2.5 Policy Issues

2.5.1 Regulation

The National Waste Management Council of Environment and Forest, of which State Municipal Commissioner and Environment Secretaries are members, periodically discusses plastic waste management practices to arrive at future strategies. The National task force on plastic waste management is also set up by the Ministry of Environment and Forestry. The Ministry has issued criteria for labeling plastic products as environmentally friendly under "Ecomark Scheme" in association with Bureau of Indian Standards. These criteria suggest end use of recycled plastic products. Bureau of Indian Standards has also developed specifications for thermoplastic products such as molded briefcases, packaging material, reflector and light fittings, and polythene buckets (TPMA, 1995). However these standards and specification are not mandatory and hence non-enforceable.

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CHAPTER 3 PLASTIC RECOVERY : PROCESS, PRACTICES AND FINANCIAL ANALYSIS

Part I: PROCESS AND PRACTICES

3.1 Recovery of Plastic Waste

3.1.1 Waste Picker

According to a study conducted in 1994 there are 25,000 waste pickers in Bangalore (Asha, 1991). Waste pickers collect plastic as one among the other waste material and typically plastic accounts for 47.8 % (weight wise) (Shyamala, 1994) and constitute 36% of his/her total income. Although metal fetches maximum amount of return per unit weight, plastic is the most attractive material for waste picking. The amount of metal reaching waste stream is very less compared to paper and plastic. Paper has inherent character to be soggy if spent more time in waste bin. Besides, clean paper waste like News Paper, Notebooks and Magazines do not reach community waste bin at all. Hence, plastic becomes relatively significant material for waste picking.

However, not all plastic is collected by waste pickers. Only that plastic which has direct salable value is picked up as waste picking is primarily an economic activity. Widely sought after materials in Bangalore include all items made of HDPE, LLDPE, LDPE, HMPE and PP. Milk sachets and carry bags are regular items collected by a waste picker. A close observation of the waste pickers activity revealed that not all types of the plastic has salable value. Small bits of plastic, contaminated with food material or dust and mud are not collected. Even milk sachets are left uncollected if highly contaminated and smelly. Plastic covers on medicine strips, bottles used for packing edible oil, cold drink bottles like Pepsi etc., are some of the striking examples of uncollected material. Furthermore, composite plastics, for example used for packing chips, tea, chocolates etc., are not taken obviously as they can not be recycled easily.

Generally a waste picker sells his/her waste everyday. The collected plastic matter may be further sorted into milk sachets, *Pugga*, road waste and mixed category (or *Masala* as it is known in their language). There seems to be no standardization in classifying the collected waste as what plastic waste falls in what category depends on the waste picker's perception and his/her capacity to negotiate price. It is felt that at this level the plastics which can be easily associated with its previous use are put in *Pugga*, those which can not be easily identified are labeled as mixed, which also contains carry bags, and small, contaminated bits are packed in road waste category. Milk covers are either categorized as *Pugga* or kept separately if given better price. Majority of the waste pickers interviewed told that around 10 % of plastics collected is discarded by the Junk Dealer before paying the price.

3.2 Kabadiwala

Kabadiwalas (or cyclewala) collect waste directly from household. The quality of their waste is, therefore, higher. They collect milk sachets, which are separately kept after washing, bottles, broken buckets, baskets, toys and other household items. Since the collected waste is generally sorted and stored by householders not much sorting is required by a *Kabadiwala*. On an average plastic items account for 14% of their income.

3.3 Middle Dealer

The main sources of waste collection are waste pickers, *Kabadiwalas*, servants, citizens, institutions and industries. As per an assessment the share of supply is as follow: waste pickers (28 %), factories (25 %), Households (24 %), *Kabadiwalas* (19 %) and institutions (4 %). This is a broad figure covering all types of waste and does not indicate supply of plastic material. On an average plastics amounts for 35 to 45% of sales of a Junk Dealer's shop.

A Junk Dealer runs his business in a small shop generally located in a residential area. It is estimated that Bangalore has 600 and odd number of Junk Dealers shops. A shop barely measures a maximum of 20 ft x 20 ft and is piled up with sorted and unsorted waste. Sorting is done either in the open space in front of the shop or near his residence. A few may have access to an open plot, generally a public property. Shops have minimum accessories like weighing scale and generally do not have electricity.

A fixed number of waste picker supply at his place. Prices are negotiated and are not changed frequently. A waste picker’s reputation with a Junk Dealer brings him/her a better price rather than the quality of the waste for, regularity of waste supply is more important for a Junk Dealer than quality. The relationship between waste pickers and Junk Dealers is a mutual one. In exchange of the regular supply of waste, a Junk Dealer extends credit to a waste picker. A Junk Dealer may use waste pickers services for sorting and in turn either give him place to stay or protect him from police harassment. It is essential for both the parties to build long lasting relationship for the success of their respective businesses. In addition, labor of a relative staying at Junk Dealer's place and other family members like wife and children may also be employed for sorting.

A major investment for a Junk Dealer is towards land and building. In most of the cases, the shop is rented for a fixed advance which is the only investment other than the money spent for the weighing scale. He has to have working capital for a month in his hand before starting the business. Investment money is raised from family sources. Loans, other than small credits from Wholesalers in time of need, are least expected. Sometimes money is raised by selling the village land or borrowed from village sources.

It takes time to understand the intricacies of waste business. Before starting his own business a Junk Dealer generally works at a relative's shop either as a shop keeper or as a *Kabadiwala* and

inherits contacts along with business skills. A waste picker starting his own business as Junk Dealer is very rare.

The waste is sold generally once a week as a shop has storing capacity of a week's waste. Each Junk Dealer has a set of regular customers and different categories of waste are sold to different Wholesalers specialized in the categories of waste. Depending upon the demand transportation charges are borne by the either of the party. If in need of waste, Wholesaler sends a tempo, otherwise transportation charges are born by the Junk Dealer.

3.3.1 Sorting

Depending upon his capacity a Junk Dealer sorts waste in to the varieties mentioned below. However, only the highest and the lowest level of sorting generally done at this stage are mentioned below. Between these extreme levels of sorting, there exists range of levels of sorting.

Lowest Level of Sorting

Plastic waste is sorted into two types: all colors of carry bags of five varieties, milk covers and other plastic bags are baled together; and hard plastic known as *Pugga* containing buckets, canes, *Kodams*, bottles etc., are packed as the other category. Milk covers are either packed with *Pugga* or kept separately.

Highest Level of Sorting

Plastic is sorted in following varieties.

- ⇨ *Pugga*: hard plastic, buckets, baskets, canes, toothpaste covers, disposable cups, cosmetics and detergent bottles, etc.
- ⇨ *Karak*: Lids of all bottles.
- ⇨ Soft footwear, one variety of plastic bag made of HMPE.
- ⇨ Milk covers, oil and *Ghee* covers, thick variety of plastic packing bag.
- ⇨ Super white plastic thick cover (for example packing bag for Surf detergent powder).
- ⇨ Hard footwear and broken lids.
- ⇨ *Kala*(black) *Pugga*: same as *Pugga* but black in color.
- ⇨ Carry bags are sorted in five different colors (rose, blue, green, white and yellow).
- ⇨ Sanitary pipes, irrigation pipes (hard), electric conduits.
- ⇨ Water pipes (soft).
- ⇨ Article: comb, switches, iron handles etc.(sometime acrylic sheets are kept in this category).
- ⇨ Sheet *Kadak*: window planks, vegetable cutting planks, radio case, cassette covers etc.
- ⇨ *Kadak*: is like *Pugga* but different type of plastic. This type releases fresh and pleasant smell immediately on breaking.

Above varieties indicate only broad categories of sorting and not the exact description of the material sorted.

3.4 Wholesalers

Wholesaler generally deal with one category of waste. A plastic waste Wholesaler purchases waste from Junk Dealers, institutions, shops and industries. Waste is sorted according to type of plastic at this level. The separate categories of plastic such as PP or PE or PVC are recognised hence forth. The methods generally adopted for sorting are still the same. While sorting knowledge of type of plastic and its previous utility is more relied upon than any other method for sorting. However, a bucket made of PP or HDPE is ascertained by smelling the plastic after breaking. Typical categories in to which the collected waste is sorted is presented in the financial analysis.

A Wholesaler sells waste directly to the industry. His contacts (which are built through years of experiences in the business) with the suppliers and end users of waste is the key factor for his business. As in the case of Junk Dealer, the Wholesaler supplies to regular customers. The Wholesaler also exports waste outside Bangalore for which they need to obtain permit for movement of waste across the border of various federal states.

Plastic Wholesalers are located mainly in Jolly Mohalla in Bangalore. A shop and godown typically measures around 2000 sq. ft. Many of them have a separate shop for the business dealings and the waste is sorted and stored in the godown.

As in the case of MIDDLE DEALER, main investment for a Wholesaler is land and building. The Wholesalers contacted for this study received support from the family and raised money through private loans at interest rate as high as 2 % to 5 % a month.

PART II: FINANCIAL ANALYSIS, CASE STUDIES

3.5 Waste Picker

A typical analysis of the quantity and type of waste collected by waste pickers is presented bellow. The results are based on sample of 55 respondents, mainly women, from *Kuntigrama* slum and 61 respondents, mainly men, from *Bharatmata* slum. Generally, a waste picker goes for waste picking on an average 17 to 20 days a month.

Table 1.1 Quantity and Type of Material Collected

Type	Amount Kg/day	Price Rs./kg	Total Rs./day
Paper			

Brown Board	15-20	0.75	13
Card Board	3-4	2.50	10
Record	5-6	2.50	15
Plastic			
Road Waste	4	2.00	8
Pugga and Milk Covers	2-3	9.00	24
Kadak	2	6.00	12
Glass			
Beer Bottle	5-6 No.	2.00/No	12
Whisky Bottle	10 No.	0.75/No	7.5
Phenyl and Small	2-3 No.	0.50/No	1.5
Metal (all)	1	20	20
Total Rs./day			123

Considering waste picking for 17 days a month, total income per month = Rs. 2091

3.6 Kabadiwala

The following representation is aggregate of 11 Kabadiwala interviewed in Malleswaram area of Bangalore.

Table 2.1 Quantity and Type of Material Collected by Kabadiwala

Type	Quantity Kg/day	Buying Price Rs./kg	Total Buying Rs./day	Selling Price Rs./kg	Total Selling Rs./day
Paper					
News Paper English	30	3.50	105	4.00	120
News Paper Kannada	25	3.00	75	3.50	88
Card Board	10	2.00	20	4.00	40
Magazines	12	2.00	24	2.50	30
Plastics					
Milk Covers	3	6.00	18	8.00	24
Plastic Bottles/Items	3	8.00	24	12.00	36
Glass					
Bottles Big	7	0.50	3.5	0.75	5
Beer	11	1.50	16.5	2.00	22
Whisky	5	1.00	5	2.00	10
Phenyl	10	0.50	5	0.75	8
Metal (all)	2	10.00	20	20.00	40
Total Rs./day			316		422

Profit = Rs. 106 per day x 26 days = Rs. 2756 /Month

3.7 Middle Dealer

3.7.1 Sharvana Paper Mart
J.P. Nagar II Phase

This shop is located in a residential area. The shop measures around 15 ft x 20 ft but open space in front of the shop is used for sorting and packing activities. The open space measures around 30 ft x 40 ft. Twenty two waste pickers and eight *Kabadiwalas* sell their waste to this shop regularly. Besides, residents also directly sell their News Paper to this shop. The sorted waste is stored in godown located nearby and sold to Wholesaler weekly once.

The shopkeeper was working as a *Kabadiwala* in J.P. Nagar and Jayanagar area. He used to sell his collected waste to his uncle's shop. In 1980, he opened his shop with the assistance of his uncle and capital raised from his village. Initial capital was spent towards the land, building and purchase of scales etc.

None of the waste picker stay with him. His wife and brother help him in managing business. He has a small godown, 20 ft x 30 ft, near his place to store the sorted waste.

Financial Data Analysis

Running Cost

Table 3.1.1. Waste Material and Purchase Price

Material Type	Volume Dealt with Kg/Day	Volume Dealt with Kg/Week	Purchase Price Rs./Kg	Total Purchase Price Rs./Week
Plastic				
Road Waste	75	450	2.00	500
Pugga	40	240	8.00	920
Kadak	15	90	6.00	540
Super	5	30	9.00	810
Milk Covers	10	60	5.00	540
Paper				
Record	60	360	3.00	1080
Brown Board	150	900	0.60	540
News Paper	80	480	4.00	1920
Card Board	70	420	2.00	840
Magazines	40	240	3.50	840
Metal				
Metals Mixed	15	90	10.00	900
Iron	20	120	4.00	480
Glass				
Broken Glass	20	120	0.50	60
Whisky Bottles	8-10 No.		0.50	225
Big Bottles	18 No.	108 No.	0.75/No	81
Small Bottles	18 No.	108 No.	0.50/No	54
Beer Bottle	25-30No.	162No.	1.00/No	162
Total				12372
Total Rs. Month				49488

Table 3.1.2 Other Inputs

Type	Total Rs./Month
Transportation	1600
Labor for Sorting (1 Man and 2 Women)	3000
Others and Electricity	1000
Total	5600

Capital Cost

Table 3.1.3 Assets

Asset	Investment Rs.	Capital Cost Rs.
Land and Bldg		30,000
Evary Scale	4000	
Weighing Scale	2000	
Bale Box	400	
Weights	1000	
Total	7400	37,400

Table 3.1.4 Sale after Sorting

Material Type	Amount Kg/Week	Selling Price Rs./Kg	Total Selling Price Rs./Week
Brown Paper	720	0.70	504
Card Board (Brown)	240	3.00	720
Card Board (Other)	120	5.00	600
Record I	200	4.50	900
Record II	210	3.50	735
News Paper English	480	6.00	2880
News Paper Kannada	160	4.00	640
Carry Bags	427	4.00	1708
Milk Covers and Super	156	13.00	2028
Pugga	60	12.00	720
Black *Pugga*	36	7.00	252
Bucket Items	50	14.00	700
Hard Pieces or Sheet Kadak	40	15.00	600
Chappal	20	6.00	120
Cable Wires and Pipes	25	8.00	200
Copper	16	55.00	880
Iron	20	6.00	120
Aluminum	24	35.00	840
Tin	40	5.00	200
Steel	10	18.00	180
Bottles	360No	2.00/No	720
Broken Glass	150	0.75	113
Beer Bottles	160 No.	3.00 No.	480
Big Bottles	100 No.	1.00 No.	100
Small Bottles	100 No.	0.75 No.	75
Whisky Bottles	56 No.	2.00 No.	112
Total			16407

Total = Rs. 65,628 per Month

Gross profit before depreciation and interest

Sales	65,628 Rs. per Month
Less Marginal costs	55,088 Rs. per Month
Total	10540 Rs. per month

Depreciation 10% on plant and machinery

7400 = 740/12 = Rs. 62 per Month

Interest on investment 12% Per annum

37400 =4488/12 = Rs. 374 per Month

Total Rs. 435 per Month

Net profit.

Gross profit	10540 Rs. per Month
Less Interest and Depreciation	435 Rs. per Month
Total	10105 Rs. per Month

Rentability Analysis

1. Product ratio = 16140/65628 x 100% = 24.59%

2. Gross profit ratio = 10540/65628 x 100% = 16%

3. Return on investment =10105/37400 x 100% = 27%

4. Financial capacity analysis
   Interest ratio =374/10105 x 100% = 3.7 %

5. Vulnerability analysis

   a) Quality ratio = 47000/52000 x 100 = 90.38 %

      Note: This ratio is calculated only for plastics purchased and sold by the junk dealer. Purchase price of different plastic scrape is averaged out to Rs. 5000 /ton. The average sale price of virgin plastic is taken as Rs. 52,000 per ton.)

   b) Fixed costs ratio =37400/65628 x 100% = 56.98 %

   c) Net Profit ratio = 10105/65628 x 100 = 15.39 %

3.7.2 Vazeer Ahemad
Bharatmata Slum
Pillana Garden
Bangalore - 560 045.

Vazeer belongs to Bangalore. He first started a cycle mechanic shop when he moved in to Bharatmata slum in 1989. Later, he started his own scrap with the help of a relative who deals with metal and iron scrap. Metal scrap is easily available on Tannery road and number of waste pickers in the slum of his residence sold appreciable quantity of scrap. He started his shop within the slum in the corner of his home and later expanded it to his sister's house. At present, 8-10 waste pickers and surrounding households supply their waste to him.

Financial Data Analysis

Running Cost

Table 3.2.1 Raw Material

Type	Volume Dealt Kg/Day	Volume Dealt Kg/Week	Purchase Price Rs./Kg	Total Purchase Price Rs./Week
Paper				
Brown Board, Card Board, Record Mixed	160	960	0.70	672
Record	15	90	2.50	225
Plastic				
Road Waste	24	168	3.00	504
Milk Covers and *Pugga*	20	120	8.00	960
Kadak	17	102	9.00	918
Metal				
Tagadu and Metal	6	36	6.00	216
Kabuni	40	240	5.00	1200
Bottles				
Liquor Bottles and Brown Bottles	65No.	360 No.	1.00/No.	360
Total				5056
Total Rs. per Month				20224

Table 3.2.2 Other Inputs

Type	Total Rs./Month
Rent	300
Transportation	650
Labor for Sorting	2500
Others	350
Total	3800

Capital Cost

Table 3.2.3 Assets

Asset	Investment Rs.
Weighing Scale	2000
Bale Box	400
Weights	1000
Total	3000

Table 3.2.4 Sale after Sorting

Material Type	Amount Kg/Week	Selling Price Rs./Kg	Total Selling Price Rs./Week
Brown Paper	890	0.80	712
Card Board	40	3.50	140
Record	120	3.00	360
Carry Bags	168	4.00	1032
Milk Covers	50	12.00	600
Pugga	35	18.00	630
Bucket Items	35	18.00	630
Hard Pieces	60	6.00	360
Chappal	15	7.00	105
Cable Wires and Pipes	28	6.00	168
Iron	240	6.00	1440
Aluminium	9	40.00	360
Tin	14	5.00	70
Steel	13	14.00	132
Bottles	360No	2.00/No	720
Total			7509
Total Rs. per Month			30036

Gross profit before depreciation and interest

Sales	30,036 Rs. per Month
Less Marginal costs	24,024 Rs. per Month
Total	6012 Rs. per month

Depreciation 10% on plant and machinery

3000 = 300/12 = Rs. 25 per Month

Interest on investment 10% Per annum

6000 = 600/12 = Rs. 50 per Month

Total Rs. 75 per Month

Net profit.

Gross profit	6012 Rs. per Month
Less Interest and depreciation	75 Rs. per Month
Total	5937 Rs. per Month

Rentability Analysis

1. Product ratio = 9821/30036 x 100% = 32.66%

2. Gross profit ratio = 6012/30036 x 100% = 20%

3. Return on investment = 5937/6000 x 100% = 99%

4. Financial capacity analysis
   Interest ratio = 50/5987 x 100% = 0.83%

5. Vulnerability analysis

   a) Quality ratio = 45333/52000 x 100 = 87 %

      Note: This ratio is calculated only for plastics purchased and sold by the junk dealer. Purchase price of different plastic scrape is averaged out to Rs. 6666 /ton. The average sale price of virgin plastic is taken as Rs. 52,000 per ton.)

   b) Fixed costs ratio = 6000/30036 x 100% = 20 %

   c) Net Profit ratio = 5937/30036 x 100 = 20 %

3.7.3 Gora Babu
Vasanth Nagar
Near Cantonment Station
Bangalore

Babu started his business in 1980. Prior to that he was working as a *Kabadiwala* in his Uncle's shop. He worked there for 6 years. He hails from Nagucoil from Tamilnadu and came to Bangalore in 1974. While working with his Uncle he developed contacts with wholesalers. Eventually, some of the waste pickers selling to his Uncle started selling to him and with his Uncles financial help he started his own business. He also occupied an open space near his residence in a slum as a storage place. At present, 8-10 waste pickers supply to him.

Financial Data Collection

Running Cost

Table 3.3.1 Raw Material

Type	Volume Dealt Kg/Day	Volume Dealt Kg/Week	Purchase Price Rs./Kg	Total Purchase Price Rs./Week
Brown Board, Record Mixed	136	816	0.75	612
News Paper	6	33	3.00	99
Card Board	49	294	2.25	661
Road Waste	40	240	2.00	480
Milk Covers, *Pugga* and Mixed	42	250	8.00	2000
Tin	0.25	9	3.00	27
Iron	20	120	4.00	480
Beer Bottles	50No.	300 No.	1.00/No.	300
Whisky Bottles	70No.	420 No.	0.75/No.	315
Big Bottles	20No.	120 No.	0.50/No.	60
Total				5034
Total Rs. per Month				20136

Table 3.3.2 Other Inputs

Type	Total Rs./Month
Rent	600
Transportation	640
Labor for Sorting	1920
Others	500
Total	3660

Capital Cost

Table 3.3.3 Assets

Asset	Investment Rs.
Weighing Scale	2000
Bale Box	400
Weights	1000
Total	3000

Table 3.3.4 Sale after Sorting

Material Type	Amount Kg/Week	Selling Price Rs./Kg	Total Selling Price Rs./Week
Brown Paper	720	2.00	1440
Card Board	294	2.50	735
Record	96	3.50	336
News Paper	33	4.00	132
Milk Covers	75	12.00	900
Pugga	45	14.00	675
Bucket Items	48	16.00	768
Road waste	240	3.00	720
Cable Wires and Pipes	75	6.00	450
Iron	120	5.50	660
Tin	9	4.00	36
Beer	280 No.	2.00/No.	560
Whisky	60 No.	1.00/No.	60
Big Bottles	100 No.	1.00/No.	100
Broken	75	0.50	37
Total			7610
Total Rs. per Month			30440

Gross profit before depreciation and interest

Sales	30,440 Rs. per Month
Less Marginal costs	23,796 Rs. per Month
Total	6644 Rs. per month

Depreciation 10% on plant and machinery

3000 = 300/12 = 25 Rs. per Month

Interest on investment 10% Per annum

6500 = 650/12 = 54 Rs. per Month

Total 79 Rs. per Month

Net profit.

Gross profit	6644 Rs. per Month
Less Interest and depreciation	79 Rs. per Month
Total	6565 Rs. per Month

Rentability Analysis

1. Product ratio = 10304/30440 x 100% = 33.85%

2. Gross profit ratio = 6644/30440 x 100% = 21.82 %

3. Return on investment = 6565/6500 x 100% = 101%

4. Financial capacity analysis
   Interest ratio = 54/6565 x 100% = 0.82%

5. Vulnerability analysis

   a) Quality ratio = 47000/52000 x 100 = 90.38 %

      Note: This ratio is calculated only for plastics purchased and sold by the junk dealer. Purchase price of different plastic scrape is averaged out to 5000 Rs./ton. The average sales price of virgin plastic is taken as 52,000 Rs. per ton.)

   b) Fixed costs ratio = 6500/30440 x 100% = 21.32 %

   c) Net Profit ratio = 6565/30440 x 100 = 21.56 %

3.7.4 Ibrahim

Nagashettyhalli Main Road
RMV Extension, Bangalore - 94

Ibrahim started his waste buying shop in 1976 with the help of his elder brother who is a small wholesaler in Jolly Mohallah. Prior to starting this shop, he was working in his brothers shop. Initially he was purchasing waste from 10 -12 waste pickers living in the slum where he was staying. In 1983, he rented the shop from where he is operating at present. Besides this shop, he has two more shops which are managed by his younger brother and his son. Around 25 waste pickers and 12 *kabadiwalas* are selling their waste to him. The waste materials purchased in the three shops are stored in a godown situated in his slum. Data presented in this section is based on the quantities bought and purchased in one shop.

Financial Data Analysis

Running Cost

Raw Material

Type	Volume Dealt Kg/Day	Volume Dealt Kg/Month	Purchase Price Rs./Kg	Total Purchase Price Rs./Month
Paper				
Brown Board	97	2520	0.70	1764
News Paper English	97	2520	5.00	12600
News Paper Kannada	92	2400	3.00	7200
Magazines	35	920	4.00	3680
Card Board	38	990	2.50	2475
Record	82	2136	2.50	5340
Plastic				
Road Waste	17	450	2.00	900
Pugga and Mixed	15	402	8.00	3216
Kadak	14	354	6.00	2124
HDPE	6	144	10.00	1440
Metal				
Tin	35	840	4.00	3360
Iron	50	1200	5.00	6000
Steel	50	1200	10.00	12000
Mixed	3	65	20.00	1300
Bottles				
Beer Bottles	40No.	1040 No.	2.00/No.	2080
Whisky Bottles	90No.	2340 No.	0.75/No.	1755
Phenyl	35No.	840 No.	0.50/No.	420
Small Bottles White	15No.	360 No.	0.50/No.	180
Small Bottles Color	25No.	600 No.	0.40/No.	240
Total Rs. per Month				68074

Other Inputs

Type	Total Rs./Month
Transportation	12800
Labor for Sorting	10400
Others	4000
Total	27200

Capital Cost

Table 3.4.3 Assets

Asset	Investment Rs.	Advance Rs.
		40,000
Weighing Scale	2000	
Every Scale	4000	
Weights	1000	
Total	7000	47,000

Table 3.4.4 Sale after Sorting

Material Type	Amount Kg/Month	Selling Price Rs./Kg	Selling Price Rs./Month
Brown Paper I	2270	2.00	4540
Brown Paper II	250	1.00	250
Card Board	900	4.00	3600
Record I	1210	4.00	4840
Record II	900	3.00	2700
News Paper English	2520	6.00	15120
News Paper Kannada	2400	4.00	9600
Magazines	920	4.00	14720
Carry Bags White	150	4.00	600
Carry Bags Color	115	3.00	345
Milk Covers	150	13.00	1950

Pugga	170	14.00	2380
Kala Pugga	75	9.00	675
Bucket Items	180	14.00	2520
PP White	150	5.00	750
PP Color	150	4.00	600
Kadak Light	90	14.00	1260
Kadak Heavy	70	18.00	1260
Karak	30	40.00	1200
Iron	1200	7.00	8400
Tin	840	5.00	4200
Aluminum	20	58.00	1160
Brass	12	75.00	900
Copper	28	100.00	2800
Rods	1200	20.00	24000
Beer Bottles	1000No.	2.50/No.	2500
Whisky Bottles	2000No.	1.00/No.	2000
Phenyl Bottles	840 No.	0.75/No.	630
Small White Bottles	360 No.	0.75/No.	270
Small Color Bottles	600 No.	0.50/No.	300
Broken Cullets	300	0.50	150

Total Rs. per Month = 1,16,220 Rs.

Gross profit before depreciation and interest

Sales	1,16,220 Rs. per Month
Less Marginal costs	1,02,274 Rs. per Month
Total	13946 Rs. per month

Depreciation 10% on plant and machinery

7000 = 700/12 = 58 Rs. per Month

Interest on investment 10% Per annum

47,000 =5640/12 =470 Rs. per Month

Total 528 Rs. per Month

Net profit.

Gross profit	13946 Rs. per Month
Less Interest and depreciation	528 Rs. per Month
Total	13417 Rs. per Month

Rentability Analysis

1. Product ratio = 48146/116220 x 100% = 41.42%

2. Gross profit ratio = 13946/116220 x 100% = 12 %

3. Return on investment =13417/47000 x 100% = 28.54%

4. Financial capacity analysis
   Interest ratio =470/13417 x 100% = 3.5 %

5. Vulnerability analysis

   a) Quality ratio = 45500/52000 x 100 = 87.50 %

      Note: This ratio is calculated only for plastics purchased and sold by the junk dealer. Purchase price of different plastic scrape is averaged out to 6500 Rs./ton. The average sales price of virgin plastic is taken as 52,000 Rs. per ton.)

   b) Fixed costs ratio =47000/116220 x 100% = 40.44 %

   c) Net Profit ratio = 13417/116220 x 100 = 11.54 %

3.8 Wholesaler

3.8.1 Razaque Bhaiya
III rd Cross, S.G. Narayana Layout
J.C. Road
Bangalore

Before starting this business in 1982, Razaque Bhaiya was involved in leather business. He moved to Bangalore from Tamilnadu as he incurred loss in leather business. He first joined his two brothers involved in waste plastic and metal trade. They eventually helped him to set up business of his own. He owns one godown-cum-shop and one godown originally purchased by his brother in 1975. He deals only with plastic waste. He gets waste from 8-10 Junk Dealers, 6-8 *Kabadiwalas*, 4 companies and institutions and a few shops from J.C. road. He also receives oil and Jerry cans from shops located on J.C. road.

Financial Data Analysis

Running Cost

Table 4.1.1 Raw Material

Type	Volume Dealt Kg/Week	Volume Dealt Kg/Month	Purchase Price Rs./Kg	Total Rs./Month
Pugga	2400	9600	15.00	1,44,000
Kadak	970	3880	21.00	81,480
Hard Pieces	800	3200	7.50	24,000
Chappal (Foot Wear)	500	2000	8.00	16,000
Carry Bags	2000	8000	8.00	64,000
HDPE Bags	900	3600	15.00	54,000
Total Rs. per Month				3,83,480

Table 4.1.2 Other Inputs

Type	Total Rs./Month
Transportation	25000
Labor for Sorting 1. Men (2) @ Rs. 1500 per Month 2. Women (2) @ Rs. 1000 per Month 3. Boys (8) @ Rs. 80 per Day, 3 days a week 4. Loading, unloading, transporting	12200 3000 2000 2880 4320
Others	5000
Total	42200

Capital Cost

Table 4.1.3 Assets

Asset	Investment Rs.	Advance Rs.
		55,000
Weighing Scale	4000	
Every Scale	4000	
Weights	2000	
Total	10000	65,000

Sale after Sorting

Material Type	Amount Kg/Month	Selling Price Rs./Kg	Selling Rs./Month
Pugga			
HDPE (*Kodams*, Cans)	2000	20.00	40,000
LDPE (Toilet Items)	1200	16.00	19,200
LDPE (Cans, Buckets)	900	4.00	21,600
HDPE and PP	1840	16.00	29,440
PP Black	600	20.00	12,000
Leyland Sheet (Bus Seat Covers etc.,.)	400	12.00	4800
HMPE (Bags, Stopper etc.,)	720	15.00	10,800
PVC Items	1000	22.00	35,200
Kadak			
PVC + PP	800	12.00	9,600
ABS	1600	20.00	32,000
Acrylic Sheet	900	14.00	12,600
Gown Katha (Items made of Virgin PVC)	280	20.00	5,600
Hard Pieces			
Black PVC	1200	9.00	10,800
White PVC	800	10.00	8,000
Derlyne (Drips etc.,)	800	10.00	16,000
x-ray Items	100	40.00	4,000
Slipper			
Foam	640	10.00	6,400
Sandak	720	10.00	7,200
Hard Pieces	720	11.00	7,920
HDPE Bags			
HDPE Bags	2400	14.00	33,600
Super Bags	1800	15.00	27,000
Carry Bags			
PP I	2000	20.00	20,000
PP II	900	8.00	7,200
LDPE Bags	2400	10.00	24,000
HM Bags	1600	8.00	14,400
Rejected Bags	400	6.00	2,400

Total = Rs. 4,67,760 per Month

Gross profit before depreciation and interest

Sales	4,67,760 Rs. per Month
Less Marginal costs	4,25,680 Rs. per Month
Total	42,080 Rs. per month

Depreciation 10% on plant and machinery

10000 =1000/12 = 83 Rs. per Month

Interest on investment 10% Per annum

55,000 =6600/12 = 550 Rs. per Month

Total 633 Rs. per Month

Net profit.

Gross profit	40,080 Rs. per Month
Less Interest and depreciation	633 Rs. per Month
Total	41,447 Rs. per Month

Rentability Analysis

1. Product ratio =84280/467760 x 100% = 18.10%

2. Gross profit ratio = 42080/467760 x 100% = 9 %

3. Return on investment =41447/55000 x 100% = 75.35%

4. Financial capacity analysis
   Interest ratio =550/41447 x 100% = 1.32%

5. Vulnerability analysis

   a) Quality ratio = 39583/52000 x 100 = 76.12 %

      Note: The purchase price of different plastic scrape is averaged out to 12416 Rs./ton. The average sales price of virgin plastic is taken as 52,000 Rs. per ton.)

   b) Fixed costs ratio =55000/467760 x 100% = 11.75 %

   c) Net Profit ratio = 41447/467760 x 100 = 8.86 %

3.8.2 Mahaboob Ali Khan
Asian Plastic Traders
16/1 Jolly Masjid Road
Bangalore.

His business is 11 years old. Prior to starting waste shop he had retail shop for waste purchase in Bamboo Bazar and provision stores. With expanding business his four sons also joined him and they restricted themselves to plastic purchase and selling. He owns a small blow mounlding plastic recycling unit as well.

Financial Data Analyais

Running Cost

Raw Material

Type	Volume Dealt Kg/Week	Purchase Price Rs./Kg	Total Rs./Week
Pugga	650	20.00	13,000
Kadak	400	25.00	10,000
Super	700	15.00	10,500
PVC	500	15.00	7,500
Road Waste	1200	12.00	14,400
Total Rs. per Month			2,21,600

Other Inputs

Type	Total Rs./Month
Transportation	15000
Labor for Sorting 1. Men (2) @ Rs. 1950 per Month 2. Women (4) @ Rs. 1040 per Month	8060 3900 4160
Rent	6000
Water	600
Electricity	300
Telephone	2000
Total	31960

Capital Cost

Table 4.1.3 Assets

Asset	Investment Rs.	Advance Rs.
Advance		40,000
Weighing Scale	4000	
Other equipement	2000	
Total	6000	46,000

Sale after Sorting

Material Type	Amount Kg/Week	Selling Price Rs./Kg	Total Selling Price Rs./Week
Milk Covers	200	19.00	3,800
Arrak (Country Liquor) Covers	300	20.00	6,000
Oil Covers	100	18.00	1,800
Nirma/Surf Covers	50	18.00	900
Jerry Cans/Bucket Items	250	25.00	6,250
Kala Pugga	100	22.00	2,200
Pen	50	22.00	1,100
LDPE (*Kodams*, Bucket Items)	200	25.00	5,000
PVC Items	500	28.00	14,400
Kadak (light)	250	32.00	8,000
Kadak (heavy)	100	40.00	8,000
HDPE Bags (white)	100	20.00	2,000
LDPE Bags (white)	100	16.00	1,600
PP (white)	400	15.00	6,000
PP (color)	200	14.00	2,800
HMPE (white)	100	18.00	1,800
HMPE (color)	100	18.00	1,800
Total Rs. per Month			4,67,760

Gross profit before depreciation and interest

Sales	2,93,800 Rs. per Month
Less Marginal costs	2,53,560 Rs. per Month
Total	40,240 Rs. per month

Depreciation 10% on plant and machinery
6000 = 600/12 = 50 Rs. per Month
Interest on investment 10% Per annum
46,000 =4600/12 = 383 Rs. per Month
Total 433 Rs. per Month

Net profit.

Gross profit	40,240 Rs. per Month
Less Interest and depreciation	433 Rs. per Month
Total	39,806 Rs. per Month

Rentability Analysis

1. Product ratio =72200/293800 x 100% = 24.57%

2. Gross profit ratio = 40240/293800 x 100% = 13.69%

3. Return on investment =39806/46000 x 100% = 86.53%

4. Financial capacity analysis
   Interest ratio =383/39806 x 100% = 0.96%

5. Vulnerability analysis

   a) Quality ratio = 34600/52000 x 100 = 66.50 %

      Note: The purchase price of different plastic scrape is averaged out to 17400 Rs./ton. The average sales price of virgin plastic is taken as 52,000 Rs. per ton.)

   b) Fixed costs ratio =46000/293800 x 100% = 15.65 %

   c) Net Profit ratio = 39806/293800 x 100 = 13.54 %

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CHAPTER 4 PLASTIC REPROCESSING: PROCESS, PRACTICES AND FINANCIAL ANALYSIS
CHAPTER I: PROCESS AND PRACTICES

4.1 Definition

"Plastic is an organic material which on application of adequate heat and pressure can be caused to flow and take up a desired shape which will be retained when the applied heat and pressure are withdrawn." Chemically, a polymer is defined as a substance composed of very large molecules. The molecular structure corresponds to a chain composed of many small molecules joined by chemical bonds. One or more types of small molecules, also known as monomers, are incorporated into the polymer as it is synthesized in control conditions (Brandrup, 1975).

From the view point of recycling, plastics (or polymers as it is known in the language of material sciences) can be subdivided in two main categories: thermoplastics, which consists of individual long chain molecules and any product made of this plastic can be reprocessed; and thermoset plastics which contain infinite three dimensional network which is formed when the product is in the final form and can not be broken down by reheating (Brandrup, 1975). Hence, for the purpose of this report only thermoplastics are analysed.

By definition plastics can be reheated and modified in different shape. Theoretically this process can be repeated number of times but practically it depends upon the physical conditions in which it is processed and reprocessed.

4.2 Reprocessing

4.2.1 Types of Polymers Reprocessed

Polyolefins

Polyolefins are the world's most important class of polymer in terms of volume usage and simplest in terms of composition. They are long chain hydrocarbons consisting of polymer of alpha-olefins, with molecular weight ranging from a few thousands to few millions. There are various varieties of polyolefins and they differ from one another in molecular weight. Polyolefins are the thermoplastics with easy processing and reprocessing characteristics and hence widely sought after polymer for recycling all over the world.

Important varieties in this category are: Polyethylene-Low Density(LDPE) has moderate degree of crystallinity (50%) because the molecular chain has numerous short chain branches. It is non brittle plastic with easy processibility, moderate hardness and low softening temperature. Polyethylene-High Density (HDPE) has little or no branching or side chains. It has higher stiffness, strength and melting point. Polyethylene-Linear Low Density (LLDPE) has a degree of

crystallinity and properties generally intermediate between conventional high and low density polyethylene. Commercially available Polypropylene has high degree of crystallinity, high stiffness, strength and melting point (Mcmillan, 1996; Ross, 1996).

Table 4. Important Properties of Polyolefins

Property	Units	LDPE	LLDPE	HDPE	PP
Melt flow	g/10 min	9.3	12.6	8.2	9.6
Density	g/cm	0.92	0.932	0.95	0.902
Viscat Soft Temp.	0_C	92	106	122	143

Source: Mcmillan, 1996.

PVC

Polyvinyl chlorine resin, or PVC are derived from vinyl chloride monomer in which vinyl chloride accounts for 50 to 100% by weight. Vinyl chloride monomer is a gaseous, chlorine containing hydrocarbon. In world wide commercial importance, PVC resins outrank other polymers in terms of application and total tonnage of the products made. PVC is unique in another sense that it is least stable for the commercial use. A host of the additives are required to increase the processibility and heat resistance capacity. In addition to antioxidants, fire resistants, impact modifiers etc., are added. Additives sometimes comprise 60% by weight of a finished product.

PVC has remained controversial all through due to two reasons: the toxic hazards posed by the industries producing vinyl chloride and other additives and probable impact of products of the plastic when in use and when subjected to the extreme environment. The impact is not only on those workers coming in intimate and prolonged physical contact with the material in question but also influences the larger population in a variety of ways.

PVC, as such is difficult to process without stabilisers and plasticisers. Reprocessing is even more difficult as additives are consumed in the first cycle itself and contaminants make it more susceptible to degradation (Batiuk, 1977).

4.2.2 The Process

In-house Sorting and Cleaning

Methods of Sorting

All types of Polyethylene are compatible and great care is not taken to separate them, although the previous use largely determines the type. However, PP and PVC require careful separation from each other and from PE, as all the three have different molecular weight and hence different

melt flow index and viscat flow temperature. For example, HDPE contaminated with PP can lead to polymer segregation as PP melts at 40^{O} C higher than HDPE, whereas PET remains solid at normal processing temperature and any unmelted PET present can quickly plug melt delivery channels. The difference in densities gives the potential to separate them.

Generally, visual methods and judgements are employed to differentiate between the types of plastics. These methods depend on the knowledge of type of plastic used for the manufacture of the original product. Others in use include touch, feel and sound methods. When these methods are proven insufficient, the plastic is broken and smelled or burnt. The nature of smell or fire decides the type. This method, though scientifically proven is rarely used in practice.

Instead, water with different densities is used to separate PP, PE, PS and PVC. When soaked in water all PE and PP float having densities less than water, whereas PS and PVC settle down. To further separate PP from PE and separate all varieties of PE alcohol is added in water to reduce density less than one. In 25 liters of water 2-3 liters of alcohol is added to make PP float. On further addition of alcohol LLDPE and LDPE float and HDPE sinks. The mixture of PVC and PS are separated in salt water with density more than one, wherein PS floats and PVC sinks. This method, although used frequently, is not considered accurate as some varieties of plastics can not be identified on the basis of density. For example, some grades of PP settles with PVC and PS. This can cause problem at the time of melt processing. Hence, visual methods are considered most reliable.

Milk sachets are generally purchased after they are separated from other plastic sheets and then cut and cleaned manually. They are further fed into beater where mud, sand and other heavy contaminants are removed by pounding. The same is then washed in automatic washer for two to three times and dried before converting into chips which are fed into the extruder. Similar procedure is followed for carry bags and other plastic sheets.

A. Polyethylene

When waste reaches the reprocessing industry it is fairly sorted as the industry generally purchases one variety of the scrap. For example the industry may purchase scrap mainly containing buckets, mugs, baskets, *kodams*, toys or milk sachets or carry bags or shampoo and detergent bottles etc. Sorted material in terms of their previous use ensures uniformity of the material being reprocessed. Further, sorting based on color is done in-house if the scrap contains mixture of buckets, *kodams*, mugs etc. This helps to achieve uniform color of recyclate but more importantly it ensures uniformity of the scrap being recycled. By thumb rule more times the plastic is recycled the more it becomes darker and dull. To camouflage the degraded patches dark blue, green, red and ultimately black color are added at the time of reprocessing. The color and shine of the plastic scrap is therefore an important indicator to decide how many times it might have been recycled. It is important to separate more time recycled scrap from the other scrap to ensure quality. This judgement requires knowledge and experience based on practice.

For example, blow molded water carriers (locally known as *Kodams*) made of HDPE are available in three qualities: Rafiya which is the highest grade and is made from used fertiliser sacks or from milk sachets; the next quality grade is known as super which is made from one time used bottles like Johnson powder and detergent bottles; and, the lowest quality medium grade is made from once used *Kodams*.

B. Polypropylene

Polypropylene is used for thin carry bags, buckets, *Kodams*, household items, automobile spare-parts, sacks etc. Different types of carry bags are separated on the basis of sound they make when rubbed between two hands. PP gives crisp and cracking sound compared to other plastics. In case of confusion the edge of the plastic is burnt to identify PP which gives a scented smell. This requires skilled, experienced workers. While separating, bags are also cleaned manually to broadly remove dust and mud and no other washing is done. These bags are then fed into extruder to be converted into lumps which are crushed and again extruded to make granules. Sometime the lumps are straight used to make blow molded suitcases.

Items like automobile spare parts are further sorted to remove nylon or PVC items and then ground. The chips are put, with or without washing, in to high speed mixer to remove moisture. If required the masterbatch of the color is mixed at this stage. The chips are fed into the extruder at high temperature and converted into lumps which are again extruded to make granules or straight used for product making. In a similar way, buckets, baskets, mugs and household items are reprocessed. The reprocessed granules or lumps are used to make battery separator, buckets, mugs, *Kodams* and household items.

C. PVC

It is not difficult to differentiate PVC from other plastic items. Footwear, drainage and water pipes, irrigation pipes, electric conduits are the main PVC items which appear in the waste stream. Uniform type is very essential for PVC recycling and hence generally one type of waste is purchased from one wholesaler.

Garden hose, footwear and electric conduits are recycled into footwear and drainage pipes. PVC rigid pipes and medicine covers are recycled into conduits and rigid pipes. Generally, waste is not washed before it is ground. The chips are sometimes put in the water to ascertain the type vis-a-vis other plastics.

Size Reduction

Once uniformity of plastic to be reprocessed is ensured the material is reduced in size depending upon type of plastic. Thin carry bags of LDPE, LLDPE or even PP are directly fed into extruder with or without washing. Hard plastic like buckets, baskets, mugs etc. are fed into shredder and converted into flakes or chips of around 3 mm diameter. Whereas HDPE bags are cut and

converted into chips. This operation ensures uniformity in the size of input material and hence higher output.

Both, vertical axis and horizontal axis, locally fabricated shredders were found in use. The matter is fed at the top and the chopped flakes are collected at the bottom. This is a very noisy operation which also generates dust. In many places shredders are operated in such a way that few cut pieces are thrown out at high velocity. Covering the input and output sides with a cloth bag is a simple remedy to prevent both cut pieces and dust emissions.

High Speed Mixing

If extruder screw is started when the matter inside is not properly heated, excessive load will be created on mechanical drive. It will tend to generate high pressure when forced through the die and either the die centering will shift or, in more severe cases, some part of the die will break. Such a condition, known as "cold extrusion" is avoided by heating the matter at about 140^{o} C-150^{o} C for about 15-30 minutes before starting the extruder.
The second function of high speed mixing, besides increasing the bulk density and homogeneity of the matter, is to mix additives and colors. Adequate mixing is essential to achieve uniform color and shade (Balachandani, 1980).

Coloring

Second or third time recycled plastic has to be colored to cover the degraded patches and also to give new, uniform look. Previously coloring was done with powdered pigments which is still followed by a few reprocessors. Major disadvantage of this method is that different batches of the same colored matter fed into extruder get different shades in spite of strict controlling of the amount of pigments added. Also, the different shades are obtained with same amount of pigments added if the matter is extruded at different temperature. In addition, the color is not uniformly dispersed throughout. These disadvantages are overcome with the method of adding color in the form of "masterbatch". Masterbatch is a capsule of concentrated colors with certain additives: Silicon Dioxide for uniformity and handling ease, dispersing agents like easter and waxes and coupling agents like salts of Silicon and Titanium. These additives are mainly to improve the color mixing and have no impact on processing. Few brands of masterbatch are available in market and the exact formula of different ingredients is generally maintained as a business secrete.

Commonly used colors are Titanium oxide (white), Thelocynine (green and blue), Scarlet City and Iron Oxide (red), Benzandine (yellow), and Cadmium (red) in addition to carbon black. Most of the color pigments are complex organic compounds, usually with a metal chelate, which provides the typical color. Common pigments are thallocyannins, e.g., blue, green, red etc. Metals present include Cadmium, Copper, Iron, Tin etc. It is often seen that the pigments used by the reprocessors are not always standard, with some pigments not being clearly identifiable as to their composition etc.

Pigments used form a small proportion of the plastic being reprocessed, of the order of 0.1% of the plastic by weight. Thus, in a typical reprocessing unit having a production capacity of 400 Kgs per day, the amount of pigment used is about 0.4 Kgs, equivalent to a metal usage of 0.05-0.1 Kg per day.

Carbon black is usually added to make the material black in color. While other pigments are added with a dispersing agent to prevent dust formation, in case of carbon black no such agent is used, probably because with carbon black there would be dust anyway. Carbon black is usually colloidal in size, and tends to deposit everywhere, and can also be inhaled and deposited in the lungs.

Additives

The basic Polymers to which the plastic industry owes its existence are in most cases unsuitable for processing into useful articles in their pure unmodified form.

Plastic additives may be divided into two main categories: those which modify Polymer properties by physical means, such as plasticiser, lubricants, impact modifiers, fillers, pigments etc.; and, additives which achieve their effect by chemical reactions such as PVC heat stabilisers, antioxidants, ultraviolet absorbers and flame retardants.

PVC with its susceptibility requires maximum number of additives. A plasticiser improves flexibility and processibility and alters temperature dependent properties. A widely used plasticiser added for reprocessing is dioctyl phthalates. This plasticiser, although known for its low toxicity and low volatility and ease of handling besides being cheap, has poor extraction properties, is inflammable and unsuited for continuous use at elevated temperatures. Tribasic lead sulphate, dibasic lead sulphate and lead stearate are most commonly used stabilisers to prevent decomposition at the normal processing temperature. These stabilisers are cheap, efficient but are toxic and should not be preferred for food packaging. However, PVC is rarely recycled into food packaging articles. Calcium stearate, glysrene mono stearate, paraffin wax and hydro carbon wax are commonly used lubricants in reprocessing of PVC. In addition, fillers are added to lower the cost of composition. Additives are added and mixed in high speed mixer but actually compounded when passed through the extruder.

All Polymeric materials are subject to oxidative degradation at elevated temperature necessary for processing. Antioxidants- phenolic compounds should be added to combat the effect of oxidation during reprocessing as well as subsequent service life. Particularly polyolefins are more susceptible to oxidative degradation at processing (for that matter reprocessing as well) temperature and unless compounded with antioxidants not only the subsequent service life is severely shortened but odorous elements are also produced when being extruded. However, for reprocessing of Polyolefins additives are very rarely used except pigments, which in fact, promote the oxidative degradation. This part is further discussed in the chapter on Environmental Effect (Nass, 1977; Beadle, 1971; Chanda, 1987).

Extrusion

A plastic material is forced through an orifice of the required shape under pressure to achieve the desired section. This is the fundamental principle of the extrusion. Extrusion is the crucial operation and extruders are widely used machines in processing and reprocessing of plastics. As per an estimate, 50 % of the main thermoplastics consumed are finally extruded. However, extruders are also used for various other purposes of plastic processing, namely, as reactors, melt pumps, compounders, devolatilisers etc. (Schenkel, 1966; Brydson, 1973). Extrusion for reprocessing purpose fundamentally follows the same technology as for processing.

History

In a broad sense the extrusion of plastic materials is known for at least hundred and fifty years. The first patent was granted in 1845 for an extruder for processing of thermoplastics. The development of continuously operating extruders for thermoplastics began in the middle of nineteenth century in the large cable factories of England and Germany. However, the real boost for commercially available extruded plastics came with the world war II. Flexible PVC insulating coating for electrical wires and cables represent the earliest commercial application for extruded plastic during world war II (Schenkel, 1966). Technically, the extruder employed for reprocessing is essentially same as the one utilised for processing.

Types of Extruders

A. Single Screw Extruders

By far the most common type of extruder used in plastic industry is single screw machine. The principle features of single screw extruder are: screw, barrel, hopper as a feed pocket, mechanism to revolve the screw, head and die assembly, heating and cooling mechanism of the barrel and temperature control mechanism as shown in Figure 1.

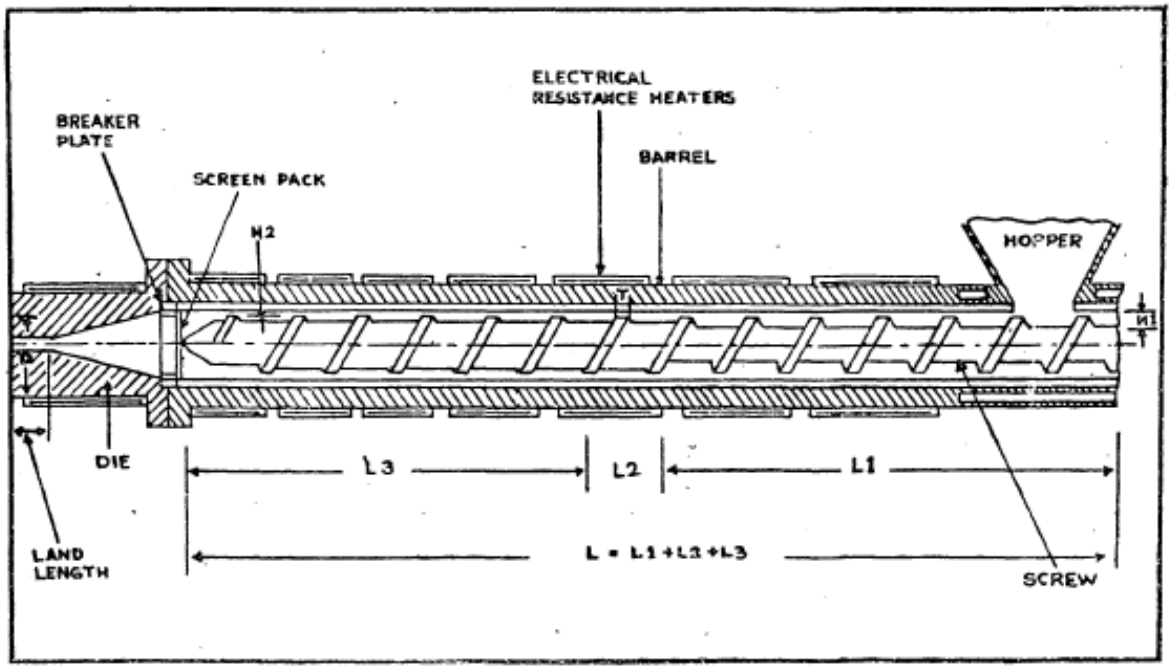
The extruder machines are generally heated by electric resistance heaters although many other forms of heating may be found, for example, steam, oil etc. Electrical resistance heaters are used in India for processing and reprocessing of plastics. Ideally, the temperature regulation of the extruder barrel is fully automatic. For this purpose the barrel is divided into a number of zones to allow variation of temperature along the length. Similarly, cooling is done with air or water as heat transfer media (Braun, 1971).

B. Twin Screw Extruders

Twin screw extruders find their main application in the extrusion of unplasticised PVC and for more difficult compounding applications. For all practical purposes twin screw extruders are not used for reprocessing in India.

C. Vented Extruders

Specially designed vented extruders have degassing zone to remove the volatile matter. The vented extruders are considered as landmark achievement in extrusion technology, although they are hardly used in India. The concept and design of vented extruders are further discussed in the next section (Deutcher, 1980; Brydson, 1973).



EXTRUDER SCREW & BARREL

The Extrusion Process: Theory

The barrel and screw section of the extruder has four principle functions: pumping, heating, mixing and pressurising. The length of extruder can be divided in to three zones: a feed zone starting at hopper, followed by a compression zone and then a melt or metering zone.

The granules or flakes are collected in the feed zone from feed hopper and transported up the screw channel. The granules/flakes begin to heat up and compact, building up pressure as they advance down the screw. For efficient pumping the granules/flakes must not be allowed to stay in the screw channel. As the matter shifts from feed zone to melt zone there is an increase in the screw diameter. This will cause compression of the matter forcing the air trapped in between back towards the hopper. The melting should occur around the compression zone. In the melt zone the polymer is brought to correct consistency and pressure required for extrusion. A high melt pressure is required in the metering zone in order to mix the melt to give it constant properties throughout and to obtain smooth extrudates. This pressure is generated by restrictions to flow in the melt zone and die head. It will also increase with an increase in melt viscosity (by lowering the melt temperature) (Brydson, 1973; Balachandani, 1980).

Breaker Plate

At the end of melt zone there is a breaker plate. This is usually perforated disc of greater thickness. This has several important functions. It helps to further increase back pressure, it turns rotational flow of the melt into flow parallel to the screw axis, it holds back impurities and it

holds back unplasticised material. The ability of breaker plate to fulfill these functions are enhanced by interposing wire mesh screens between breaker plate and screw.

Temperature Control

The Melt Flow Index is a rough measure of the molecular weight and melt viscosity of the Polymer. It indicates how readily molten Polymer will flow in processing machinery. It is a function of temperature, molecular weight of the Polymer, shear generated by the screw speed, pressure and contaminants present in the polymer. In other words, the resistance to flow under specified temperature and pressure conditions is called Melt Index. Theoretically developed Melt Index do not take into account the actual conditions of processing but is a reasonably accurate indicator to predict how Polymer will behave when processed.

Lower the Melt Index value of the Polymer higher the viscosity, hence processing low Melt Index Polymer will require higher operating temperature and more mechanical power in the processing equipment. Moreover, due to difference in such flow properties mixing of two batches of widely different Melt Index Polymers would give very poor finishing surface or may make processing difficult or even impossible. Melt Flow Index denotes wide range of temperature at which the Polymer will be melt viscous under processing and reprocessing conditions (Mark, 1989). The temperature for Polyolefin is denoted in Table 1. PVC free from additives can start degrading at temperature as low as 50^0C but generally is processed at 175-180^0C compounded with various additives.

Large part of the melting occurs at the interface between melt film and solid bed. Heat is conducted from the hot barrel surface through the film into the interface. Furthermore, the relative velocity of barrel and screw shears the thin film thus generating considerable amount of heat by viscous dissipation. It is necessary to control heat supply because if the material becomes excessively hot it may decompose, degrade or become too fluid. If excessively cold it will be insufficiently plasticised. Variations in temperature will also cause variations in flow rate. In order to optimise the efficiency, temperature is varied along the barrel. Two to six heating zones are normal with a steady temperature gradient increasing from the feed to die. Temperature control in all these zones is very crucial and should be achieved by the automatic temperature control mechanism and by cooling the parts of the barrel with air or water circulation (Balachandani, 1980).

Degassing

Polymer melts may contain varying amount of air, moisture, solvent or monomer. These contaminants may be removed by applying vacuum and allowing volatile to diffuse out for quality output. Otherwise this causes extrudates to bubble and exhibit porosity (Deutcher, 1980). Contaminants like air and moisture, in case of polyolefin, promote oxidization and eventually degradation at the time of processing. This can be reduced by using a screw with decompressing zone with a sudden change in the diameter of the screw. The flight in the decompression zone

will have no pressure on the melt. A vent hole is drilled at this point in the barrel to allow gases to escape added with vacuum (Brydson, 1973).

Extrusion Process: Practice

Extruders generally used for reprocessing in Bangalore are locally fabricated in the workshops or in the industry itself. It is very common to fabricate extruders from second-hand or discarded machinery and have bare minimum parts. It was a usual sight that heaters and electrical wiring connected with barrel are exposed without any casing. The wiring, in many cases, was connected without even insulation tapes. In such case, the proper design of the screw to suit the type of the polymer being reprocessed and auotomatic temperature control can not be expected. The extruders are single screw type with or without increasing root diameter from feed to metering zones. The vented extruders are rarely used as the cost of such machines is manyfold higher than the non-vented ones.

The temperature range for melting particular type of Polymer is fixed on the basis of practice. There are two ways of temperature control: manual off and on of heaters or cooling with water manually. The automatic temperature control systems known as Pyromatric temperature control system which automatically disconnects when temperature exceeds the prescribed limit are rarely used. The second system of temperature control, wherein heating can be stopped for set timing, say 10 % or 20 % of the heating time, are also not commonly used as they are difficult to maintain. Generally, manually switching on and off systems are used in addition to cooling the barrel manually with water.

Flakes or chips are preheated in high speed mixer and fed into the hopper. The matter is then pushed into the barrel with long spade or wooden stick to maintain continuous flow with relatively high pressure. The process normally starts with hot barrel to achieve maximum benefit of the heat generated due to shear and heat conducted through barrel. A high screw speed and low temperature setting is the ideal condition when all the heat may come from viscous dissipation. The heating of the barrel creates the thin film of the melt on the solid bed and once this is formed the heaters can be disconnected. Acheivemtn of this equilibrium demands lot of efforts and in most of the reprocessing cases is not achieved simply because the process is interrupted number of times due to contaminants clogging the wire mesh. Hence, manual cooling the barrel with water in addition to switching off the power supply in extreme condition is the only means of temperature control. The machine operator keeps a jug of water handy and ready and pours it on barrel now and then.

Aarriving at a right kind of processing temperature suited to particular kind of Polymer is also a task of the skilled operator. Although type of the Polymer being reprocessed is known, the characteristic features like number of times reprocessed before, level and types of contaminants, molecular weight (with each reprocessing the molecular weight of the Polymer is likely to decrease by 30 % to 40 %) which influence the actual processing are largely unknown. Hence, arriving at right kind of reprocessing conditions is an art more than the science. The rate of out

flow and homogeneity of the plastic coming out are indicators to decide the correct temperature which may differ widely for the same type of polymer.

Breaker Plate

A wire mesh is attached to the breaker plate to remove contaminants. There is invariably a fair amount of impurities in the shredded material loaded into extruder. The mesh placed before breaker plate is meant to trap these impurities. In normal operation the mesh gets clogged very fast, and needs to be replaced almost every minute. This causes frequent, though very short, stoppages of extrusion, and again results in variations in temperature and a reduction in production. As a result the actual production is about 50% of the total capacity. Thus most units, which have a production capacity of 400 Kgs per day, actually produce only 200-250 Kgs per day. The increased energy losses in turn lead to uncomfortable working conditions. Wire mesh is changed manually and then burnt to remove impurities. The breaker plate is also burnt at least once a day.

Power Shutdowns

Bangalore faces a severe shortage of power supply. As a consequence there is a power shutdown of 2 hours each every morning and afternoon. In addition, industries are barred from using power from 6 P.M. to 10 P.M. This has a considerable impact on the production and the extrusion process. Extrusion is usually a continuous process, and in ideal conditions the machine runs non-stop for a run of one week or more.

Frequent stoppages for replacing the mesh do not cause a large drop in the temperature of the barrel and the die. Production is thus interrupted only when the stoppage occurs. However, in case of power shutdowns, the barrel and the die cool down considerably, and take about an hour to heat up. This causes, first, a considerable drop in the production and second, material in the barrel of extruder solidifies and needs to be reheated, leading to degradation and loss. This particularly causes problems in case of PVC as long residence time at elevated temperature in the extruder leads to degradation. When the degraded material is removed from extruder after power is restored, highly odorous volatile matter is emanated which may contain toxic vinyl chloride, hydrogen chloride in addition to carbon monoxide and other products of incomplete combustion.

Pelletising or Lump Making

Actual extrusion is through a cylindrical die, with usually 6mm diameter holes through which the plastic is squeezed out. As the semi-solid material emerges, it is passed through a trough of water to harden, and then passed into a chopper which chops it into small pellets. During this pulling through water the cord thins further, to reduce the diameter to about 2mm at the chopper. In case of PP, first lumps are made which are again ground and extruded to make granules. Finally the granules are again extruded to be molded into appropriate product shape.

Plastic thus recycled is passed through the extruder 2-3 times before reshaped into final product.

4.3 Environmental Impact of Recycling

- **Physical Environment:**
  Grinding scrap is a noisy operation. Some times noise level may go up to 95 db. Small scale enterprises are often not designed for the reprocessing purpose. Adequately designed ventilation to quickly remove the gaseous products and heat is generally not present. Lack of space for easy movement makes it further congested.

- **Cleaning:**
  Caustic Soda and other cheap detergents are used for cleaning. The flakes or chips are soaked in detergent for anywhere between 1 to 3 days. Before rinsing they are washed with hands. This operation would require a worker to keep her/his hands in soap solution for 6 to 8 hours a day.

- **Grinding:**

Major products of grinding are RPM[2] (respirable particulate matter) and SPM (suspended particulate matter). Air quality monitoring (the results are attached as annexure) in one of the plastic reprocessing unit in Bangalore revealed RPM = 241 mcg/cu.m and SPM = 1491 mcg/cu. m.

- **Coloring**
  With the addition of color in the form of masterbatch the harmful effects of powder pigments are curtailed. Nevertheless, the leaching out effect of pigments in the final product is a complex phenomenon and it has to largely do with the conditions of reprocessing and type of the pigments used.

- **Extrusion**
  ⇨Impact of Heating

    It involves the mechanical scission of polymer chain in its viscous environment. This produces highly reactive microradicals that in the presence of small amount of oxygen dissolved in the polymer can form peroxyl radicals and hydroperoxides. As a result hydrogen is abstracted from each C-H bond leading to rapid reduction in molecular weight. This has two manifestations, one, the polymer becomes more susceptible to

[2] Smoke arising of heating and grinding processes comprise soot, fine dust and ash in a mixture of gases. Size of particles range from 0.5 to 100 micron particle size. Particles above 10 micron size known as suspended particulate matter (SPM) do not enter human breath, between 5 to 10 micron size are retainedin upper respiratory tract and particles less than 5 microns, known as respirable paniculate matter (RPM) reach lungs. 75 mcg/cu.m. is the proposed higher limit for RPM in India (Agrawal, 1996).

degradation and second, its tensile strength is considerably reduced making subsequent product life shortened.

Overheating can lead to degradation and gaseous matter generated as a result can even cause extruder blow up. This was reported particularly in case of PP. Thin carry bags made of PP are carefully separated from PE and extruded into lumps. Here the presence of air, moisture or even other polymer can lead to degradation and clogging of the screw channel. When there is no venting point point for volatile matter, there can be explosion given high temperature (Papaspyrides, 1996; Chanda, 1987).

⇨Impact of Pigments

The pigments used are mostly based on inexpensive metal oxides that acts as prooxidants at high temperature at the time of extrusion. Some of the pigments, for instance chromium based green pigment, can catalyse the thermooxidative degradation of HDPE when present even in trace quantities. Virgin PE is usually stabilised to prevent in-service degradation but with processing this antioxidants are consumed and these pigments may exert prodegradant effect. Since reprocessed Polyolefins are rarely stabilised the pigments further promote degradation when the product is subjected to heat, light and pressure in service (Scheirs, 1996).

⇨Impact of Contaminants

The various contaminants present may be due to labelling content, packaging content, the products with which plastic come in contact with during the service life, contamination with other polymers and contamination due to environment and additives. During the in service use plastic may be photodegraded and can form low molecular weight oxygenated products like aldehydes, acids, ketones, waxes etc. These low molecular weight impurities can lead to segregation at the time of reprocessing and further sensitise the reprocessed polymer to photodegradation (Scheirs, 1996).

⇨Volatilisation

Polymer passes through the mechanochemical changes each time it is heated to be extruded. In the most common form the polymer passes through the molecular chain scission and eventual cross linking. Depending upon the material, the temperature and the presence or absence of oxygen and other harmful gases may also evolve. These include HC, HCN, NO_2 , SO_2, carbon monoxide and chlorinated gases. The impact of additives and pigments on the composition of products of heating is not much known as it varies widely (Deutcher, 1980).

⇨Degradation

The stability of the polymer against thermal degradation and chemical nature of thermal decomposition vary widely from one material to another. The stability of the polymer

depends upon heat history it has been subjected to, the contaminants present and molecular weight (Williamson, 1992). It is absolutely impossible to know the heat history of the polymer being recycled given the level of technology used for both processing and reprocessing. Each time it is heated to be molten it becomes more prone to degradation unless the previous heat history (rate and intensity of heating and cooling) is repeated. First or second time recycled plastic contains fair amount of contaminants and that makes it more susceptible to degradation. Lastly, each time the polymer is subjected to heating to be molten its average molecular weight decreases which also has profound effect on its stability against degradation. Hence, even under the normal conditions of reprocessing part of the plastic is subjected to degradation unless heat stabilisers are added (which are rarely added in case of polyolefins). Besides, there are low flow regions in the machine known as "hang up" zones where, material is likely to be stuck up and degrade.

The real threat is posed by frequent power fluctuation in Bangalore. If there is power failure when the machine is in running condition there is no way that the matter stuck up inside can be removed. The machine has to be reheated to process the matter after power is restored. In such a situation material degrades being subjected to repeated heating particularly in case of PVC.

Lastly, the contaminants filtered by assembly of wire mesh and breaker plate are removed by burning. These contaminants also contain gels or black specks and unplasticised particles. When burnt these elements are subjected to decomposition.

- **Products of Degradation**

This is highly unpredictable part of the polymer science. Various additives and other contaminants present may produce complex mixture of toxic and non toxic matter in specific processing conditions which are largely unknown. On the basis of the experiments conducted in controlled conditions the following products are at least expected of degradation of the polymers. Form the point of view of identification there are three types of products of thermal degradation: substances of the lowest molecular dimension known as monomers, volatile substances produced at degradation temperature and involatile residue. The specific products of thermal degradation of some important polymers are as follow. In addition to volatile matter like carbon monoxide, carbon dioxide, NO_X, particulate matter and suit.

Polymer	Degradation Products
Polyethylene, Polypropylene	Chain fragments of various size, small amount of volatile saturated and unsaturated hydrocarbons
Poly(vinyl Chloride)	Quantitative yield of hydrogen chloride, small amount of benzene, colored tars, carbonaceous residue and saturated and unsaturated aromatic hydrocarbons

Source: Ohtani, 1996; Williamson, 1992.

- **The Product Impact**

A senior official in IPCL (Indian Petro-chemical Ltd.) reported that products made of recycled plastic can have leaching out effect wherein the outcome of in service degradation may migrate to the matter coming in contact with it. This may have serious manifestation, for example, *Kodams* (water pots) made of recycled HDPE has huge market in urban areas facing severe water shortage. They are not only used to fetch water but are also utilised to store it for drinking and cooking purposes.

The porosity of the recycled material due to partial degradation during the process of extrusion helps in both migration of substance into the polymer coming in contact with it (which eventually behaves as contaminant for the next cycle of reprocessing adding in the degradation) and extraction of products of in service degradation into the immediate matter or environment (Briston, 1974).

PART II : FINANCIAL ANALYSIS

4.4 Case studies

4.4.1 Universal Industrial Engineers

527 A Thippasandra
Bangalore 560 075
Phone No. 52 89 359
Email : balchand@giasbga.vsnl.net.in
Contact Person : Mr. Kamal Balchandani, Proprietor

History:

The unit was started in 1978 and Mr. Balchandani, a qaulified engineer, is the proprietor. Earlier he had a machinery manufacturing business. The machinery for the plastic reprocessing business he eventually set up was fabricated by himself.

Motivation:

While he was in the business of manufacturing machinery for small scale industries, he realised that there existed a good scope for plastic recycling. After he made an assessment that what it takes to get into this business he found it may be profitable and was therefore motivated to get into plastics recycling. He also has a high awareness level of environmental concerns and thought this was one way to contribute to waste management.

Recycling Process:

This small scale plastic recycling unit uses mainly road waste as raw material. However, machine waste from plastic processing industries and even virgin material is some times processed. Sorting and segregation of the road waste is done in-house by women workers, followed by size reduction, extrusion and pelletization. Sorting is done to segregate the waste by type of the plastic. Big plastic pieces are broken down manually by beating with a mallet or hammer and in the process metal parts or other pieces removed. Wastage from sorting is minimal and accounts for about 1-2% of the total. In case of PP first lumps are extruded which are then ground again to be extruded and pelletised. Following is the flow chart:

SCRAP => SORT => GRIND => WASH IF NECESSARY =>
HIGH SPEED MIXER => FEED EXTRUDER => PELLETIZING

In addition, the men and machinery are given on hire for external job work. For the job work raw material belongs to the customer. The customer sends scrap he wants to be pelletized and the unit will convert it to pellets for them.

Source of Raw Material:

From wholesale plastic dealers and plastic factories who send their waste material for recycling.

Types and quantities of plastic material recycled:

1. Poly Propylene (PP) Black*	5 ton
2. LDPE Black	2 ton
3. Mixed external jobwork	5 tons

* Black PP is the most commonly reprocessed plastic in this unit.

Location and Work Area:

The unit is located in a tile roofed shed of 2,500 square feet in a residential area. The work area is fairly clean. The ventilation needs to be improved in grinding area and in the area where process of extrusion takes place. There are no exhaust fans provided and strong smell of burnt plastic was experienced when visited. The unit has a borewell in-house. The water is used for cooling plastic wires extruded and some times for washing the plastic pieces before extrusion.

Additives Used:

1. Carbon black
2. Coupling agents
3. Pigments

All additives are used in 1 - 5% by volume of the waste reprocessed.

Type of machinery :

1 Grinder 10hp	1 no
2 High Speed Mixer 10hp	1 no
3 Extruder 75mm	1 no
4 Pelletizer 10hp	1 no

All machinery was fabricated in-house since the proprietor is an engineer and had previously a machinery fabrication business.

Capacity:

Installed Capacity	15 tons per month
Actual capacity	12 tons per month

Time taken to process one ton of plastic is from 15 to 40 hours depending on the contaminants and the power situation.

Cost of Raw Material

PP	Rs. 9000/ MT
LDPE	Rs. 8000/MT

Sales price

PP	Rs. 20000/MT
LDPE	Rs. 17000/MT

Labor costs

Male	Rs. 100 per day
Female	Rs. 50 per day

Management:

The unit is managed by the proprietor for all practical business purpose. The machine operator is trained to manage the production and 5 male and two female workers perform sorting and other work.

Financial Analysis

1. Running Cost

Raw Material

Material Type	Volume Dealt with Kg/Month	Purchase Price Rs./Kg	Total Purchase Price Rs./Month
PP	5,000	9.00	45,000
LDPE	2,000	8.00	16,000
Total			61,000

Laborers or Staff

Type	No.	Salary Paid Rs. Per Day	No of Days in Month	Salary per Month Rs.
Men	5	100.00	25	12,500
Women	2	50.00	25	2,500
Total				15,000

Inputs

Type	Cost Rs. per Month
Power and Utilities	9,000
Others	20,000
Total	29,000

2. Capital cost

Assets	Capital Cost Rs.	Advance Paid Rs.
Land and Bldg		40,000
Extruder	150,000	
Pelletiser	40,000	
High Speed Mixer	60,000	
Grinder	25,000	
Blade Sharp	15,000	
Water Pump	5,000	
Total	295,000	335,000

3. Sales

Type	Amount Kgs per Month	Sales Price Rs. per Kg	Total in Rs.
PP	5,000	20.00	100,000
LDPE	2,000	17.00	34,000
Jobwork	5,000	8.00	40,000
Total	12,000		174,000

Gross profit before depreciation and interest

Sales	Rs. 174,000 per Month
Marginal cost	Rs. 105,000 per Month
Total	Rs. 69,000 per Month

Depreciation 10% on plant and machinery

10 % of Rs. 2,95,000 / 12 Months = Rs. 2,458 per Month

Interest on investment 12% Per annum

Rs. 3,35,000 = Rs. 40,200/12 = Rs. 3,350 per Month

Total = Rs. 5,808 per Month

Net profit.

Gross profit	Rs. 69,000 per Month
Less Interest and depreciation	Rs. 5,808 per Month
Total	Rs. 63,192 per Month

Rentability Analysis

1. Product ratio = 73,000/174,000 x 100% = 41.95%
   Sales price 100,000 + 34,000 = 134,000
   Cost price 45,000 + 16,000 = 61,000
   Product margin = 73,000

2. Gross profit ratio = 69,000/174,000 x 100% = 39.65%

3. Return on investment = 63,192/335,000 x 100% = 18.86%

4. Financial capacity analysis
   Interest ratio = 3,350/66,542 x 100% = 5.03%

5. Vulnerability analysis

   a) Quality ratio =
      PP 41,000/50,000 x 100 = 82%
      LDPE 42,000/50,000 x 100 = 84%

   b) Fixed costs ratio = 335,000/174,000 x 100% = 192.52%

   c) Net Profit ratio = 63,192/174,000 x 100 = 36.31%

4.4.2 Vinayraj Plastics

59, 5th Main, Sreerampura
Bangalore 21
PH: 3350756
Contact Person : Mr Shukla / Mr. Pandey

History:

The unit, a partnership firm, was started in 1974 by Mr Shukla and Mr. Pandey, who have a background of family business.

Motivation:

Motivation for this business was the increased use of PP woven sacks in the 1970's. Knowing that large qaunities of waste would be generated from the production of woven sacks, the entrepreneur found an opportunity to recycle this good quality machine waste and therefore were motivated to set up this unit.

Recycling Process:

This small scale plastic recycling unit uses waste generated from factories and manufacturers of PP woven sacks which are used extensively in the cement and fertilizer industries. The process involves, size reduction (in some instances when the waste is in lumps), mixed with color master batches, extrusion and pelletization. There is no sorting required since the waste material is of one type. Following is the flow chart:

SCRAP => (GRIND) => HIGH SPEED MIXER (ADD COLOR) =>
FEED EXTRUDER => PELLETIZING => BALING STRAPS

Source of raw material:

From manufacturers of PP woven sacks.

Types and quantities of plastic material recycled:

1. Poly Propylene (PP) white 8 tons per Month

Sanitary and water:

The unit uses very little amount of water since the raw material is clean machine waste. The water is required only for cooling of extruded plastic.

Location and work area:

The unit is located in a commercial area of the city near the city railway station. Although the surrounding areas are busy commercial areas, the unit is located in a cross road which is relatively quiet. The shed common to many small industries in the country, is 3000 sqft and is moderately ventilated. Being a high roof and large area it does not seem very congested. The volume of light PP waste occupies much of the space during processing. The work area is fairly clean.

Additives used :

1. Pigments (Master Batch) 10 kgs/month

Type of machinery:

1. Extruder 75mm 1 no
2. Pelletizer 75mm 1 no
3. Bailing strap plant 1 no
4. Water pump 1 no

All machinery was bought in Bombay.

Capacity:

Installed Capacity	15 tons per month
Actual capacity	8 tons per month
Time required to convert 1 tons of waste	3 days
Working hours	8 hours/day
Working days	25 days/month

Cost of raw material	
PP	Rs. 35,000/ MT
Sales price	
PP	Rs. 40,000/MT
Baling straps	Rs. 60,000/MT

Management:

The unit is managed by the partners in rotation

Flow chart:

Manager (Partners)
↓
Supervisor
↓
Machine operator
↓ ↓
Labor 6 male Labor 4 female

Financial Analysis

1. Running Cost

Raw Material

Material Type	Volume Dealt with Kg/Month	Purchase Price Rs./Kg	Total Purchase Price Rs./Month
PP White	8,000	35.00	280,000
Total			280,000

Laborers or Staff

Type	No.	Salary Paid Rs. Per Day	No of Days in Month	Salary per Month Rs.
Men	6		25	
Women	4		25	
Total				17,700

Inputs

Type	Cost Rs. per Month
Power and Utilities	19,000
Others	25,000
Total	44,000

2. Capital Cost

Assets	Capital Cost Rs.	Investment Cost Rs.
Land and Bldg		500,000
Extruder	150,000	
Pelletiser	35,000	
Baling Strap Machinery	190,000	
Water Pump	10,000	
Total	385,000	885,000

3. Sales

Type	Amount Kgs per Month	Sales Price Rs. per Kg	Total in Rs.
PP Granules	4,000	40.00	160,000
Baling Straps	4,000	60.00	240,000
Total	8,000		400,000

Gross profit before depreciation and interest

Sales	Rs. 400,000 per Month
Less Marginal costs	Rs. 341,700 per Month
Total	Rs. 58,300 per Month

Depreciation 10% on plant and machinery

385,000 = 38,500/12 = Rs. 3,209 per Month

Interest on investment 12% Per annum

885,000 = 106,200/12 = Rs. 8,850 per Month

Total = Rs.12,059 per Month

Net profit.

Gross profit	Rs. 58,300
Less Interest and depreciation	Rs. 12,059
Total	Rs. 46,241

Rentability Analysis

1. Product ratio = 120,000/400,000 x 100% = 30%
   Sales price 160,000 + 240,000 = 400,000
   Cost price = 280,000
   Product margin = 120,000

2. Gross profit ratio = 58,300/400,000 x 100% = 14.57%

3. Return on investment = 46,241/885,000 x 100% = 5.22%

4. Financial capacity analysis

Interest ratio = 8,850/55,091 x 100% = 16.06%

5. Vulnerability analysis

a) Quality ratio = 20,000/55,000 x 100 = 36.36%

b) Fixed costs ratio = 885,000/ 400,000 x 100 = 221.25%

c) Net Profit ratio = 46,241 / 400,000 x 100 = 11.56%

4.4.3 Munnot Plastics Industries
Nayandahalli
Mysore Road
Bangalore - 560 039
Contact person: Mr.Kewal
Designation : Proprietor

History:

The unit is a proprietorship firm and was started by the proprietor in the year 1991.

Motivation:

The motivation for Mr. Kewal came from his desire to do a small business which does not call for much sophistication in processes and one which was simple enough for him to do.

Recycling Process:

This unit uses HDPE scrap such as buckets and other household articles. The scrap is sorted into different colors and then broken down into smaller pieces, ground, washed, dried, extruded and pelletised.

SCRAP → COLOR SORTING → SIZE REDUCTION → FEED EXTRUDER → PELLETIZING

Source of Raw Material:

Wholesale dealers.

Types and Quantities of Plastic Material Recycled:

1. HDPE waste 15 tons per month

Sanitary and Water:

The unit uses some water which is drawn from the bore well in the factory and is used to wash the soiled plastic. The spent water is let out into an open drain in the premises.

Location and Work Area:

The unit is located in the south of the city in an area which is well known for its plastic recycling units in Bangalore. This area, Nayandahalli is estimated to have nearly a hundred units which are in some way or the other involved with plastic recycling. There are many small industrial sheds of about 2000 to 3000 sqft each with AC sheet roofing. The sheds are haphazardly built with no tarred roads.

This unit occupies one such shed of 2000 sqft with poor ventilation.
The inside of the factory was poorly maintained with swarm of the mosquitoes.

Additives used :

1. Pigments (Master Batch)	10 kgs/month
2. Titanium Dioxide	10 kgs/month

Type of Machinery:

1. Extruder 75mm	1 no
2. Pelletizer 10hp	1 no
3. Water pump 1 hp	1 no
4. Washing machine 5 hp	1 no

All machinery was fabricated locally. The machinery were visibly fabricated from second hand discarded parts of the old machinery. The wires connected with the extruder for heating were all open without casing. The grinder also looked very old and was rather throwing the cut pieces out. The unit had high level of noise with poor ventilation and unhygienic working conditions.

Capacity:

Installed Capacity	30 tons per month
Actual capacity	15 tons per month
Time required to convert 1 ton of waste	2 day
Working hours	8 hours/day
Working days	25 days/month

Cost of raw material

HDPE Rs. 20,000/ MT

Sales price

HDPE Rs. 32,000/MT

Management:

The unit is managed by the Proprietor

Flow chart

Manager (Proprietor)
↓
Machine operator
↓ ↓
Labor 4 male Labor 5 female

Financial Analysis

1. Running Cost

Raw Material

Material Type	Volume Dealt with Kg/Month	Purchase Price Rs./Kg	Total Purchase Price Rs./Month
HDPE scrap	15,000	20.00	300,000
Total			300,000

Laborers or Staff

Type	No.	Salary Paid Rs. Per Day	No of Days in Month	Salary per Month Rs.
Men	4	80.00	25	8,000
Women	5	50.00	25	6,250
Machine Operator	1			2,500
Total				16,750

Inputs

Type	Cost Rs. per Month
Power and Utilities	9,000
Others	15,000
Total	24,000

2. Capital Cost

Assets	Capital Cost Rs.	Advance Rs.
Land and Bldg		40,000
Extruder	80,000	
Pelletiser	30,000	
Grinder	25,000	
Water Pump	10,000	
Washer and other	20,000	
Total	165,000	205,000

3. Sales

Type	Amount Kgs per Month	Sales Price Rs. per Kg	Total in Rs.
HDPE Granules	15,000	32.00	480,000
Total			480,000

Gross profit before depreciation and interest

Sales	Rs. 4,80,000 per Month
Less Marginal costs	Rs. 3,40,750 per Month
Total	Rs. 1,39,250 per Month

Depreciation 10% on plant and machinery

165,000 = 16,500/12 = Rs. 1,375 per Month

Interest on investment 12% Per annum

205,000 = 24,600/12 = Rs. 2,050 per Month

Total = Rs.3,425 per Month

Net profit.

Gross profit	Rs. 1,39,250 per Month
Less Interest and depreciation	Rs. 3,425 per Month
Total	Rs. 1,35,825 per Month

Rentability Analysis

1. Product Ratio = 1,80,000/4,80,000 x 100% = 37.5 %
   Sales Price = Rs. 4,80,000 per Month
   Cost Price = Rs. 3,00,000 per Month
   Product Margin = Rs. 1,80,000 per Month

2. Gross Profit Ratio = 1,39,250/4,80,000 x 100% = 29 %

3. Return on Investment = 1,35,825/2,05,000 x 100 % = 66.25 %

4. Financial Capacity Analysis
   Interest Ratio = 2,050/1,37,875 x 100 % = 1.5 %

5. Vulnerability Analysis

   a) Quality Ratio = 30,000/50,000 x 100 = 60 %
   b) Fixed Costs Ratio = 2,05,000/4,80,000 x 100 = 42.70 %
   c) Net Profit Ratio = 1,35,825/4,80,000 x 100 = 28.29 %

4.4.4 Neha Pladtics

9, Naresha Block
Venkateshpura
PH: 5467019
Contact Person : Mr Damodaran, Proprietor

History:

The unit was started in 1978 by Mr Damodaran and is a proprietorship firm. He got into business when he came to Bangalore from Rajasthan and at that time milk sachets in plastic pouches were getting popular.

Motivation:

Considering the increasing daily consumption of milk, he forecasted an opportunity for recycling the waste plastic and was therefore motivated to set up a unit to recycle the waste milk sachets.

Recycling Process:

This unit recycles milk pouches. The waste plastic pouches are purchased from wholesalers. The process involves cleaning the waste in a circular drum beater which removes the grit and mud, this is then fed to a size reduction machine which chops it into small flakes of 5-8mm. It is put into a large motor driven drum washer to remove the dried milk and other contaminants. Manual rinsing is then done twice in large basins. It is then spread out onto a large open space to dry under the Sun. When sufficiently dry, it is put in to a high speed mixer and then fed into an extruder and a pelletizer.

Being plastic of a single type, there is no sorting done except to check for contaminants by way of other plastics which sometimes creep in. This is easily sorted.

SCRAP -> REMOVE DIRT (MECHANICAL) -> GRIND (SIZE REDUCTION) ->
WASH (MECHANICAL) → RINSE (MANUAL) → HEATING (HSM) →
EXTRUSION → PELLETIZING

Source of Raw Material:

From wholesale plastic dealers

Types and Quantities of Plastic Material Recycled:

HDPE (MILK COVERS)	600 kg/day

Sanitary and Water

A fairly large quantity of water is used in this unit since the milk sachets have to be thoroughly washed. The unit has a borewell for its water supply and is drained out in an open drain out of the unit.

Location and Work Area:

The unit is located in the east side of town, on tannery road, which is a congested area. There are many small industries in this locality. The area comprises of two rooms of about 500 sqft each with a 1500 sqft open area in between which is used to dry the washed plastic flakes. There is not much ventilation in the rooms though the open area in between helps in some ventilation. The washing is also done in the open area. Cleaning and grinding is done in the front room and the pelletisation in the other.

Additives used:

1. Pigments (master batch)
2. Whitener (Titanium Dioxide & Tinopal)

1-5% by volume of plastic reprocessed

Type of Machinery :

1. Rotary drum beater/ cleaner 5hp	1 no
2. Grinder 10hp	1 no
3. Centrifugal washer 5hp	1 no
4. High Speed Mixer 10 hp	1 no
5. Extruder 75mm	1 no
6. Pelletizer 10 hp	1 no

Machinery is fabricated locally and apparently are made of lower quality machinery parts.

Capacity:

Installed Capacity	0.6 tons per day
Actual capacity	0.5 tons per day
Time taken to produce 1 ton of pellets	2 days
Working hours	8
Working days per month	24

Cost of raw material:

Milk Covers (HDPE)	Rs. 15,000/ MT

Sales price

Pellets Rs. 34,000/MT

Price of virgin HDPE material is Rs. 55/kg

Management:

The unit is managed by the proprietor.

Flow chart

Manager (Proprietor)
↓
Machine operator
↓
Asst. Operator
↓ ↓
Labor 5 male Labor 5 female

Financial Analysis

1. Running Cost

Raw Material

Material Type	Volume Dealt with Kg/Month	Purchase Price Rs./Kg	Total Purchase Price Rs./Month
HDPE Milk Covers	13,000	15.00	195,000
Total			195,000

Laborers or Staff

Type	No.	Salary Paid Rs. Per Day	No of Days in Month	Salary per Month Rs.
Men	5	80.00	26	10,400
Women	5	40.00	26	5,200
Machine Operator	1			2,500
Asst. Operator	1			1,500
Manager	1			3,000
Total				20,100

Inputs and Rent

Type	Cost Rs. per Month

Rent	8,000
Power and Utilities	13,000
Others	10,000
Total	31,000

2. Capital cost

Assets	Capital Cost Rs.	Advance Rs.
Land and Bldg		80,000
Extruder	130,000	
Pelletiser	30,000	
High Speed Mixer	40,000	
Grinder	25,000	
Drum Cleaner	15,000	
Water Pump	3,000	
Washer	45,000	
Total	288,000	368,000

3. Sales

Type	Amount Kgs per Month	Sales Price Rs. per Kg	Total in Rs.
HDPE Granules	13,000	34.00	442,000
Total			442,000

Gross profit before depreciation and interest

Sales	Rs. 4,42,000
Marginal costs	Rs. 2,46,100
Total	Rs. 1,95,900

Depreciation 10% on plant and machinery

288,000 = 28,800/12 = 2,400 Rs. per Month

Interest on investment 12% Per annum

368,000 = 44,160/12 = 3,680 Rs. per Month

Total 6,080 Rs. per Month

Net profit.

Gross profit	Rs. 1,95,900
Less Interest and depreciation	Rs. 6,080
Total	Rs. 1,89,820

Rentability Analysis

1. Product ratio = 2,47,000/4,42,000 x 100% = 55.88%

Sales price	Rs. 442,000
Cost price	Rs. 195,000
Product margin	Rs. 247,000

2. Gross profit ratio = 195,900/442,000 x 100% = 44.32%

3. Return on investment = 189,820/368,000 x 100% = 51.58%

4. Financial capacity analysis
   Interest ratio = 3,680/193,500 x 100% = 1.90%

5. Vulnerability analysis

   a) Quality ratio = 40,000/55,000 x 100 = 72.72%

   b) Fixed costs ratio = 368,000/442,000 x 100% = 83.25%

   c) Net Profit ratio = 189,820 /442,000 x 100= 42.94%

4.4.5 Contact Person: Mr. Ismail Mohamad
Nayandahalli, Bangalore

This was a small unit without any official name. The business is being run without any license. There are a few such units in Nayandahalli. What is required for such unit is a power connection, an extruder and minimum 15 ft. x 20 ft. of working space. The following details belong to one such tiny unit.

History:

The proprietor is a Muslim person and has background of scrape wholesaling. Previously he was working in pertnership with a plastic recycling unit using HDPE milk covers. He started this unit in 1994.

Location and Work Area:

The unit is located in Nayandahalli. It has a room measuring 90 ft x 32 ft and the sorting is done outside the unit under a thatch roof.

Process:

White PP carry bags are purchased from a wholesaler and further sorted to remove any possible contamination with HDPE, LDPE, LLDPE or HM bags. The skilled laborers mainly use their judgement for sorting. The common method employed for sorting is based on the sound of the bag if rubbed between two hands. PP gives cracking sound. If uncertain, the edge of the plastic is burnt, a sweet, scent smell is emanated if it is PP.

The sorted bags are directly fed into extruder without any washing or chopping. The extruded lumps are sold. Apparently the lumps are further extruded to make granules. The granules are used for blow molded suitcase making.

Sources of Raw Material:

Wholesalers of Scrap.

Type and Quantity of the Plastic Material Recycled:

PP white carry bags. 150 kgs/day

Sanitary and Water and Work Condition:

This unit operates in a small congested room. Very little ventilation makes it suffocated. As PP is recycled by controlled degradation method there was strong smell of burnt plastic when the unit was visited. We were also told that if the extruder is overheated and if the plastic contains some

amount of moisture it is likely that the extruder may explod. Such incidents seems to have happened in the past.

The work area was occupied with heaps of waste carry bags and house keeping was not very clean.

Type of Machinery:

Extruder 1 No.

It was locally fabricated, could be from second hand machinery.

Capacity

Installed Capacity 6 tons per month
Actual Capacity 150 kgs/day
Working Days in a Month 26
Working Hours in a Day 8 hours

Financial Analysis

1. Running Cost

Raw Material

Material Type	Volume Dealt with Kg/Day	Purchase Price Rs./Kg	Total Purchase Price Rs./Month
PP white carry bags	150	15.00	46,800
Total			46,800

Laborers or Staff

Type	No.	Salary Paid Rs. Per Day	No of Days in Month	Salary per Month Rs.
Men	3	80.00	26	6,420
Women	6	40.00	26	6,420
Total				12,480

Inputs and Rent

Type	Cost Rs. per Month
Power and Utilities	4,000
Others	2,000
Total	6,000

Loan and Borrowing

Source	Amount Rs.	Interest Rs./month
Private	1,50,000	3,000
Total		3,000

2. Capital cost

Assets	Capital Cost Rs.	Advance Rs.
Land and Bldg		75,000
Extruder and other Equipments	80,000	
Total	80,000	1,55,000

3. Sales

Type	Amount Kgs per Month	Sales Price Rs. per Kg	Total in Rs.
PP Lumps	3,900	22.00	858,000
Total			858,000

Gross profit before depreciation and interest

Sales	858,000 Rs. per Month
Less Marginal costs	65,280 Rs. per Month
Total	20,520 Rs. per Month

Depreciation 10% on plant and machinery

80,000 = 8,000/12 = 666 Rs. per Month

Interest on investment 12% Per annum

1,55,000 = 15,500/12 = 1,292 Rs. per Month

Total = 1,958 Rs. per Month

Net profit.

Gross profit	20,520 Rs. per Month
Less Interest and depreciation	1,958 Rs. per Month
Total	18,562 Rs. per Month

Rentability Analysis

1. Product ratio = 39000/858,000 x 100% = 45.45%

Sales price	858,000
Cost price	468,000
Product margin	39,000

2. Gross profit ratio = 20,520/858,000 x 100% = 24.00%

3. Return on investment = 12628/155,000 x 100% = 8.14%

4. Financial capacity analysis
   Interest ratio = 4,292/19854 x 100% = 21.64%

5. Vulnerability analysis

   a) Quality ratio = 40,000/55,000 x 100 = 77.00%

   (price of the virgin PP = 55,000 Rs./ton)

   b) Fixed costs ratio = 155,000/858,000 x 100% = 180.65%

   c) Net Profit ratio = 185,62 /858,000 x 100= 21.63%

4.4.6 Hindustan Plastics

285, 8th Cross, 2nd Main
Prakashnagar
Bangalore - 560 021
Contact Person : Mr Rajesh, Proprietor

History:

The unit was started in 1981 by the proprietor Mr Rajesh.

Motivation:

The motivation for this business came from the availability of waste raffia for which he had access to from known sources. In working out the feasibility he estimated the business to be profitable and offered him the line he was looking for.

Recycling Process:

This unit processes only "Raffia" which is waste PP woven sack material. This is largely machine waste (post industrial) from PP woven sack manufacturing units. The first round of the process involves extrusion for lumps making. The lumps are then ground for size reduction and again extruded in pellets. Sorting is hardly ever required since the raw material is uniform quality, post industrial waste.

SCRAP $\rightarrow$ EXTRUDE (LUMPS) $\rightarrow$ GRIND $\rightarrow$ HSM (HEAT) $\rightarrow$
FEED EXTRUDER (CORDS) $\rightarrow$ PELLETIZING

Source of Raw Material:

From PP woven sack manufacturers.

Types and Quantities of Plastic Material Recycled:

1. Poly Propylene (PP) raffia waste 15 tons

Sanitary and Water:

The unit has an open well in the premises. The water requirement is not very high and is used for circulation in the water tank to cool extruded plastic cords. Since most of the plastic used is post industrial and clean, the waste is not washed.

Location and Work Area:

The unit is located in an industrial shed of 2500 sqft in a residential area of the city. Over all ventilation is poor and there are no provisions for cross ventilation. The work area is fairly clean.

Type of machinery :

1. Grinder 25hp 1 no
2. High Speed Mixer 10hp 1 no
3. Extruder 75mm 1 no
4. Pelletizer 10hp 1 no
5. Water pump 1 no

All machinery was fabricated locally.

Capacity:

Installed Capacity	20 tons per month
Actual capacity	15 tons per month

Time taken to process one ton of plastic is 2 days.

Cost of raw material

PP	Rs 32,000/ MT

Sales price

PP	Rs 42,000/MT

Management:

The unit is managed by the proprietor.

Financial Analysis

1. Running Cost

Raw Material

Material Type	Volume Dealt with Kg/Month	Purchase Price Rs./Kg	Total Purchase Price Rs./Month
PP Woven Sack Manufacturing waste	15,000	32.00	480,000
Total			480,000

Laborers or Staff

Type	No.	Salary Paid Rs. Per Day	No of Days in Month	Salary per Month Rs.
Men	2	100.00	25	5,000
Women	3	50.00	25	3,750
Machine Operator	1			3,500
Secretary	1			2,500
Total				14,750

Inputs and Rent

Type	Cost Rs. per Month
Power and Utilities	12,000
Others	25,000
Total	37,000

2. Capital Cost

Assets	Capital Cost Rs.	Advance Rs.
Land and Bldg		60,000
Extruder	150,000	
Pelletiser	25,000	
High Speed Mixer	70,000	
Grinder	70,000	
Water Pump	5,000	
Total	320,000	380,000

3. Sales

Type	Amount Kgs per Month	Sales Price Rs. per Kg	Total in Rs.
PP Granules	15,000	42.00	630,000
Total			630,000

Gross profit before depreciation and interest

Sales	630,000 Rs. per Month
Marginal costs	531,750 Rs. per Month
Total	98,250 Rs. per Month

Depreciation 10% on plant and machinery

320,000 = 32,000/12 = 2,666 Rs. per Month

Interest on investment 12% Per annum

380,000 = 45,600/12 = 3,800 Rs. per Month

Total 6,466 Rs. per Month

Net profit.

Gross profit	98,250 Rs. per Month
Less Interest and depreciation	6,466 Rs. per Month
Total	9,784 Rs. per Month

Rentability Analysis

1. Product ratio = 10,000/42,000 x 100% = 23.80%
   Sales price Rs. 42,000
   Cost price Rs. 32,000
   Product margin Rs. 10,000

2. Gross profit ratio = 98,250/630,000 x 100% = 15.59%

3. Return on investment = 91,784/380,000 x 100% = 24.15%

4. Financial capacity analysis
   Interest ratio = 3,800/95,584 x 100% = 3.97%

5. Vulnerability analysis

   a) Quality ratio =
   PP 23,000/55,000 x 100 = 41.81%

   b) Fixed costs ratio = 380,000/630,000 x 100% = 60.31%
   6,466/630,000 x 100 = 1.02

   c) Net Profit ratio = 91,784/630,000 x 100 = 14.56%

4.4.7 *Allied Containers*
131, Lalbagh Road 4 th Cross
Near Dilip Road Lines
K.S. Gardens
Bangalore -560 027
Contact Person: Mr. Ramesh Bhatia, Proprietor

History:

Mr. Bhatia was working as an employee before 1979. In 1979 he started a *Kodam* (water pots) making unit which he closed in 1984 due to adverse credit and pay back conditions. From 1984, he is running his own unit of recycling.

Motivation:

Mr. Bhatia is a first generation businessman and though he was working as an employee earlier, he had an urge to have business of his own. Plastic recycling at that time, in 1976 was an emerging area which seemed attractive with its margins and relatively law level of investments.

Recycling Process:

This unit processes only machine waste. Much of the production is through job work, wherein machines, labor and other facilities are given on hire to an outside person who brings the raw material. A flat amount per tone of the plastic is charged. The process involves size reduction, high speed mixing followed by extrusion and pelletisation.

Source of Raw Material:

From plastic processing units.

Types and Quantities of Plastic Waste Recycled:

1. Job work - PP Woven Sack Machine Waste 10 tons per month
2. Own - PP Woven Sack Machine Waste 4 tons per month

Location and Working Area:

The unit is located in an industrial shed of 1500 sq ft area in a commercial area of the city. Ventilation is poor.

Type of Machinery:

1. Grinder 15hp 200 kgs per hour	1 No
2. High Speed Mixer 10hp 25 kg	1 No
3. Extruder 75mm/25 hp/ 30 kg/hour	1 No
4. Pelletiser 1 hp	1 No

All machinery was purchased locally.

Capacity:

Installed Capacity	15 tons per month
Actual Capacity	14 tons per month

Time taken to process one ton of plastic is 2 days.

Cost of job work	Rs. 8 per kg
Price of raw material	Rs. 15 per kg
Price of finished product	Rs. 35 per kg

Management:

The unit is managed by the proprietor, though all day-to-day supervision and operation of the factory is done by the machine operator/supervisor.

Financial Analysis

1. Running Cost

Raw Material

Material Type	Volume Dealt with Kg/Month	Purchase Price Rs./Kg	Total Purchase Price Rs./Month
PP Woven Sack Manufacturing waste	4000	15.00	60,000
Total			60,000

Laborers or Staff:

Type	No.	Salary Paid Rs. Per Day	No of Days in Month	Salary per Month Rs.
Men	5	100.00	25	12500
Women	2	50.00	25	2500
Over Time at 50 %				7500
Machine Operator	1			3000
Secretary	1			1500
Total				27000

Inputs and Rent

Type	Cost Rs. per Month
Power and Utilities	15,000
Others	25,000
Total	40,000

2. Capital Cost

Assets	Capital Cost Rs.	Advance Rs.
Land and Bldg		45,000
Extruder	120,000	
Pelletiser	30,000	
High Speed Mixer	25,000	
Grinder	45,000	
Water Pump	3,000	
Total	223,000	268,000

3. Sales

Type	Amount Kgs per Month	Sales Price Rs. per Kg	Total in Rs.
PP Granules	4000	35.00	140,000
Job work	10000	8.00	80,000
Total			220,000

Gross profit before depreciation and interest

Sales Rs. 2,20,000 per Month
Less Marginal costs Rs. 1,27,000 per Month
Total Rs. 93,000 per Month

Depreciation 10% on plant and machinery

223,000 = 22,300/12 = Rs. 1,858 per Month

Interest on investment 12% Per annum

268,000 = 32,160/12 = Rs. 2,680 per Month
Total = Rs. 4,583 per Month

Net profit.

Gross profit Rs. 93,000 per Month
Less Interest and depreciation Rs. 4,583 per Month
Total Rs. 88,462 per Month

Rentability Analysis

1. Product ratio = 80000/140,000 x 100% = 57.14%
   Sales price Rs. 1,40,000 per Month
   Cost price Rs. 60,000 per Month
   Product margin Rs. 80,000 per Month

2. Gross profit ratio = 93,000/220,000 x 100% = 42.27%

3. Return on investment = 88462/268,000 x 100% = 33%

4. Financial capacity analysis
   Interest ratio = 2,680/91142 x 100% = 2.94 %

5. Vulnerability analysis

   a) Quality ratio =
   PP 20,000/55,000 x 100 = 40.00%

   (price of the virgin PP = 55,000 Rs./ton)

   b) Fixed costs ratio = 268,000/220,000 x 100% = 121.81%

   c) Net Profit ratio = 88462/220,000 x 100= 40.21%

4.4.8 *Apex Polymer Extrusions*
7 th Main, Mico Layout
Bangalore: 560 076
Contact Person: Kamal Thakkar
Phone: 66 85 982, 6685983

History

The unit was started in 1984. The proprietor migrated to Bangalore from Gujarat. Mainly PVC is recycled in this unit. The unit is located in south Bangalore. The factory consists of 2000 sq ft area for production with two rooms and one godown-cum-sorting place measuring the same area. The house keeping is exceptionally good.

PVC electric cable wires are recycled. The raw material is obtained through a wholesaler who is a regular supplier to this unit.

Recycling Process:

The electric cables are sorted according to color and then cut into small pieces manually. The cut pieces are then ground in the grinder and put in the high speed mixer along with color masterbatch. No additives are used. The ground matter is fed in the extruder at high temperature. The pellets are either sold or used for manufacturing of irrigation pipes in-house.

Type of Machinery:

1. Grinder 15hp 1 No.
2. High Speed Mixer 10 hp 1 No.
3. Extruder 75mm/25 hp 1 No.
4. Pelletiser 1hp 1 No.

Capacity:

Installed Capacity 15 tons per month
Actual Capacity 12 tons per month

Financial Analysis

1. Running Cost

Raw Material

Material Type	Volume Dealt with Kg/Month	Purchase Price Rs./Kg	Total Purchase Price Rs./Month
PVC Electric Cables and Wires	12,000	25.00	300,000
Total			300,000

Laborers or Staff

Type	No.	Salary Paid Rs. Per Month	Salary per Month Rs.
Men	4	2,000	8,000
Women	10	900	9,000
Machine Operator	1	2,800	2,800
Total			19,800

Inputs and Rent

Type	Cost Rs. per Month
Power and Utilities, Transportation, Additives etc.,	40,000
Rent	6,000
Total	46,000

2. Capital Cost

Assets	Capital Cost Rs.	Advance Rs.
Land and Bldg		15,000
Extruder	175,000	
Pelletiser	45,000	
High Speed Mixer	45,000	
Grinder	45,000	
Total	310,000	325,000

3. Sales

Type	Amount Kgs per Month	Sales Price Rs. per Kg	Total in Rs.
PP Granules	12,000	38.00	456,000
Total			456,000

Gross profit before depreciation and interest

Sales 456,000 Rs. per Month
Less Marginal costs 365,800 Rs. per Month
Total 90,200 Rs. per Month

Depreciation 10% on plant and machinery

310,000 = 31,000/12 =2583 Rs. per Month

Interest on investment 12% Per annum

325,000 = 39,000/12 = 3,250 Rs. per Month
Total = 5,833 Rs. per Month

Net profit.

Gross profit	90,200 Rs. per Month
Less Interest and depreciation	5,833 Rs. per Month
Total	84,367 Rs. per Month

Rentability Analysis

1. Product ratio = 156000/456,000 x 100% = 34.21%

2. Gross profit ratio = 90,200/456,000 x 100% = 19.78%

3. Return on investment = 84367/325,000 x 100% = 26%

4. Financial capacity analysis
   Interest ratio = 3,250/87617 x 100% = 3.70 %

5. Vulnerability analysis
   a) Quality ratio = 21,000/46,000 x 100 = 40.00%
   (price of the virgin PVC = 46,000 Rs./ton)

   b) Fixed costs ratio = 325,000/456,000 x 100% = 71.27%

   c) Net Profit ratio = 84367/456,000 x 100= 18.50%

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CHAPTER 5 OCCUPATIONAL HEALTH IMPACT OF PLASTIC RECYCLING

Dr. Vasundhra[3]

This chapter outlines the possible health impacts on the various actors involved in the process of plastic recycling viz. the waste pickers, Junk Dealers and wholesalers involved in the recovery of plastic from the municipal waste stream and those working in the plastic reprocessing unit. Data on the possible health impact was collected through observation of the activities performed by the various actors and through informal discussion with them.

5.1 Health Impact of Waste Recovery

Waste for the reprocessing industry as mentioned in the earlier chapter, is recovered by a chain of actors starting from the waste pickers, junk dealers and the whole salers. In some communities, house to house collection of waste has been started employing the waste pickers. For the purpose of this study, a community based waste collection scheme, a Junk Dealers shop and a wholesalers shop were visited. The health risks observed during the visit is presented in table 1

[3] This paper is an abridged version of a report prepared by Dr. Vasundhara, commissioned for this Study. Dr. Vasundhra has served as Prof. Prof, and Head of Department of community medicine since 1980. She is a consultant with government of India on maternal and child health. She is also an expert on industrial health.

Table 1 Health Hazards of Waste Recovery

Actor	Activity	Possible Health Risks
Waste Picker	Collection from the bins	-Cuts and injuries due to presence of broken glass, sharps, needles which may lead to septic wounds and tetanus. -Exposure to fumes causing irritation of nose, throat and lungs. Vulnerability to upper respiratory ailments like rhinitis, shortness of breath, and asthma. -Contact with feacal matter and the risk of contracting gastrointestinal diseases and worm infestations. -Vulnerable to blood borne diseases if hospital waste is collected.
	Community Based Collection Schemes	-Exposure to sun, radiation and rain. -Vulnerable to worm infestation as waste is sorted bare hand.
Itinerant Buyer		--Injuries due to sharps in the waste. -Callosities[4] on the fingers observed . -Ergonomic problems like body ache, leg ache due to long distances traveled.
Junk Dealer	Sorting and baling	-Exposure to dust during sorting and unloading could cause allergic respiratory disorders. -Ergonomic problems like body ache, back ache and fatigue. - Eyestrain and tenosynovitis. -Chemical injury depending on the type of chemicals that they come in contact with and skin allergy. -Accidents due to sharps.
Whole saler	Washing, sorting and baling	Health risks can occur during the washing stage as cheap detergents and caustic soda are used. Continuos exposure can cause shriveled skin known as “washerman’s hands”/ Contact with washing soda may produce blisters.

[4] Hardening and drying of skin due to repeated fiction.

5.2 Health Impact of Plastic Reprocessing

Reprocessing of plastic involves the following stages: size reduction, mixing of additives, Extrusion and pelletisation. For the purpose of this study four recycling enterprises were visited and air quality monitoring test was conducted in one of the units.

The possible health impact due to the procedures adopted in the various stages are presented in the Table 2. and Table 3. presents the case studies of the four units .

Table 2 : Health Impact of Plastic Reprocessing

Stages	Possible Health Impacts
Size reduction of grinding	During this operation, tiny particles of plastic are ejected at high speed and the shredder is electrically operated. Dust particles are also generated during this operation. Ejection of particles at high speed can cause accidental injuries. Dust particles may be inhaled and retained in the lung tissue causing upper respiratory ailments. Further, contact of dust particles with skin can cause dermatitis or skin disorders.
Effect of Additives (Plasticisers and coloring pigments)	Use of stabilisers like lead sulphate or sterate which are highly toxic may enter the food chain if used for food packaging. Plasticers used in the industry are highly inflammable and can lead to fire accidents. The pigments commonly used for coloring are reported to be cadmium, cobalt, chromium, lead or selenium, titanium oxide and iron oxide. Cumulative effect of exposure to this pigment can cause injury to the body tissue. Specific health impact of the various pigments used in the industry are : ***Cadmium:*** Chronic exposure can produce nose bleeding, nausea, abdominal pain or diahorrea. Loss of weight, cough, dyspnea and pulmonary emphysema occur due to cumulative exposure. Acute poisoning can cause dryness of throat, chest pain, headache, diahorrea and weakness. ***Chromium*** : Possible hazards are dermatitis, chrome ulcers, perforation of nasal septum and carcinoma of lungs. ***Cobalt***: Respiratory distress, skin allergy and erythrocytosis occur due to chronic exposure. ***Selenium:*** Exposure to selenium fumes can cause irritation of eyes, nose and throat; ***Zinc Chloride*** at high temperature can cause respiratory distress,

	constriction of chest, dryness of throat and slight cough. ***Lead:*** This gains entry to the body through ingestion, inhalation and absorption through the skin. Hazards of organic lead sulphide compound include insomnia, loss of weight, anorexia, nausea and psychological disorder like restlessness, hallucination and suicidal tendency.
Extrusion	At this stage volatile matter is released. The vapors released are styrene and benzene. These can cause pharyngitis, rhinitis and unproductive cough. Inhalation of fumes released are chlorine and HCL can affect the upper respiratory tract and lachrynation of eyes. Vibration and mechanical friction that occur during this process can cause white fingers and continuous friction may lead to callosities.

It is to be noted that there is a long latency period between the point of exposure and the occurrence of the disorder which makes it difficult to correlate any illness to the type of exposure.

Product Manufacturing

As the combustion process during the recycling process is rarely complete and the material is porous, there is a possibility of lechate of toxic mateirals (eg.pigments) if the products are used for storing food or water.

Table 3. Case studies : The results of the case studies are presented below:.

Parameters affecting health	Case Study 1:	Case Study 2	Case Study 3	Case Study 4
End Product	Pellets	Pellets	Pellets	Irrigation pipes
Location	Residential area	Residential area	Industrial area	Industrial area
Physical Envt.				
- Congestion	No	Adequate but not well managed.	No	congested.
-Ventilation	cross ventilation provided but inadequate	Inadequate. Smoke and fumes were found lingering in the processing area. Inadequate	Good	Not available
Lighting	Adequate	Not available	Good	Adequate
-Washing facilities for employees.	Not available	very high	Not available	Not available
-Heat	very high	very high	very high	very high
-Noise	very high	very high	very high	very high
-Smoke	high		very high	high
Safety Measures:				
Use of protective equipment.	No gloves or masks given to employees.	Not used	Not used	Not used
Safety against fire	No safety norms followed regarding electrical connections.	Fire risk due to electrical connections exist.	Fire risks due to electrical connection exist.	Fire risk exist.

Parameters affecting health	Case Study 1:	Case Study 2	Case Study 3	Case Study 4
End Product	Pellets	Pellets	Pellets	Irrigation pipes
Location	Residential area	Residential area	Industrial area	Industrial area
Identified Health impacts	-Accidental injuries like burns, electric shock, eyeinjury and fire accidents - Respiratory ailments due to the dust levels present. -Noise level beyond the acceptable limits .(ref. table 3 for effects). --Dehydration possible for employees due to excessive heat. -Skin infections like "chlor acne" due to contact with pigments . -Psychological stress -Possibility of endangering reproductive health which need to be verified further.	-Heat exhaustion and skin disorders due to excessive heat in the processing area. -Fumes can cause respiratory illness. -Loss of hearing and nuisance to neighbors due to high level of noise. -Shocks, burns and fire hazard due to lack of proper electrical connections. -Accidental injuries like fall, and burns.	-Accidental injuries due to electric shock, burns and fire. -Postural problems due to loads carried, and sorting for a long time. -Respiratory ailments due to exposure to dust and inhalation of fumes. -Discomfort and health exhaustion. -Nose irritation and nausea due to the smell.	-Exposure to chlorine fumes and HCL fumes causing cough, increased sputum, breathlessness, laryngospasm and bronchospasm. -Exposure to Carbon Monoxide fumes may affect the central nervous system. -Sulphur dioxide and Nitrogen Oxide may cause tremors, paralysis and respiratory tract ailments. -Heat exhaustion and heat cramps. -Headache , irritation, fatigue and deafness due to the noise level present possible. -Dust particles present may cause fibrosis of lungs. -Possibility of affecting the reproductive health .

Parameters affecting health	Case Study 1:	Case Study 2	Case Study 3	Case Study 4
End Product	Pellets	Pellets	Pellets	Irrigation pipes
Location	Residential area	Residential area	Industrial area	Industrial area
Suggestions	Safety norms particularly for electricity to be enforced. -Improvement in physical environment by providing exhaust ventilation and washing facility. -Monitoring of air quality to be made mandatory. -Shredder design to be improved for preventing accidents	Safety norms for preventing electrical and fire hazards. Provision of protective equipments and washing facilities. Ventilation to be improved.	Design of shredder to be improved. Safety norms to be enforced.	-

5.3 Air Quality Monitoring

Air quality and noise monitoring test was conducted in one of the units located in a residential area. The test yielded the following results:

Table 4. Results of Air Quality Monitoring

Parameter	Threshold limit (mg/m)	Amount (mg/m) present in the test area	Health Impact
Suspended Particulate matter	501	1491	Respirable particulate matter less than 5microns/m can get deposited in the lung tissue. The cumulative effect can result in fibrosis. This would lead to reduction in lung elasticity and worker may suffer from breathing problems.
Respirable particulate matter	-	241	Depending on the type of particulate matter there is a risk of contracting bronchitis. Allergic rhinitis with excessive lachrynation due to eye irritation, dermatitis can also occur.
SO	< 5	11	At 5 pp.m SO causes minor irritation. It can lead to burning, dryness and pain in the nose with altered sense of smell. Severe effect will be felt at 20-50 pp.m while concentration up to 100 pp.m could prove to be fatal.
NO	5	21	NO is a powerful lung irritant. At concentration above 500 pp.m, it may lead to bronchospasm, pulmonary odema and respiratory failure . The effect of NO at various levels of exposure is as follows: Level — Effect Between 1 -5 — Lung problems 20 - 50 — Minor irritation 100 - 250 — could prove to be fatal.
CO	2000	2916	Carbon monoxide has affinity for iron. It can combine with haemoglobin to produce carboxyhaemoglobin which can alter the functioning of central nervous system. This may affect visual & auditory response; hand and eye coordination; finger dexterity, loss of memory and alterness.
Hydrocarbon	Benzene-0 CO - 30	16	Prolonged exposure to benzene can cause cancer. Benzene affects bone marrow which could lead to aplastic anaemia, haemorrage of the gums or retina and epistaxes.
Noise	75 db	96 db	Effects of exposure to noise can cause headache, fatigue irritation, raised blood pressure and deafness.

5.4 Recommendation

- ⇨ The present case studies were limited in observation and a detailed medical examination is required to confirm the health risks involved.
- ⇨ The growing demand for post-consumption recycled products is increasing exposing greater number of people to hazards of plastic reprocessing. This calls for a study on health economics of this venture.
- ⇨ As hospital waste is retrieved by the waste pickers, a study on the life cycle of plastic waste from hospitals is required.
- ⇨ Impact of plastic recycling on the reproductive health need to be studied in detail.

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CHAPTER 6 ISSUES.

This preliminary research suggests that the financial viability of plastic recycling industries may not be a sole function of inflow and outflow of money. There seems to be various other forces at work which substantially contribute towards financial effectiveness of these enterprises. Following is a suggestive overview of such factors which make these industries possible to be run on profitable level.

6.1 Plastic Recycling Industries as Small Scale Industries

The growth of plastic small scale processing and reprocessing industries, as other Small Scale Industries (SSI) in India, began in the decade of eighties with the announcement of the new industrial policy. Policy instruments adopted by the Government to encourage the growth of SSI comprised various incentives such as reservation of certain sectors for SSI, and financial and fiscal incentives (Balasubrmanya, 1995). SSI generate 38% of the total employment and has 6.77% of the total capital investment. SSI industry of rubber and plastic products, which are declared as reserved products[5] constitute 4.6% of the total number of SSI units, generate 5% of employment in SSI and has 8.4% of investment (Pain, 1990). SSI units in India enjoy following advantages,

- They are protected from competition from large scale industries, hence as per SSI policy, no industry can have more than Rs. 3,00,00,000 of investment in plastic processing and reprocessing unit.
- Many of the SSI units in India are exempted from payment of excise duty on the final products. Plastic recycled products were exempted from payment of excise duty till two years back which was increased to 7 % till recently. It is currently kept at 3 % which also is being lobbied by the plastic association to be removed.
- They are also exempted from the tiresome procedural formalities. A plastic recycling unit needs to have a power point passed by the local electricity board at the least. If they want they can register with Industrial Development Corporation which is not mandatory. As a result most of the plastic processing and reprocessing units in Bangalore has an unregistered existence. Power may be illegally drawn from the neighbouring unit, minimum of 600 sq.m. of space and an extruder can be enough to start plastic recycling business.
- Most of them having less than 5-7 employees can not be covered under labor law.
- Plastic processing and reprocessing industries are exempted from monitoring by Pollution Control Board.

On the one side, plastic recycling industries significantly benefit due to Government's industrial policy favoring them, on the other, they not only survive but play a crucial role in the overall

[5] It means that large scale industries, having more than Rs. 3,00,00,000 of capital investment, can not establish plastic recycling industries. Hence, these industries are protected from the competition from large scale industries.

development of the industrial sector with very marginal institutional support. Following are some of the issues discussed in this context with reference to plastic processing and reprocessing industry:

6.1.1 ● Finance

Majority of the plastic processing and reprocessing units seem to have raised funds for investment through personal sources and very rarely are dependent on State financing institutions. Marwari community dominantly has the ownership of plastic reprocessing units in Bangalore and also in other parts of India. It has a social structure " which although is decentralised in space, is centralized by conventions" (Solomon, 1996). As a result it has a vast and efficient economic networking and not only the business but the skills, ethos, conventions and contacts are passed from one generation to another. This may be true for any other business community in India. Not only clustering together, dominance by a particular community in business plays a crucial role in the development of the industry.

6.1.2 ● Technology

Though level of technology in the plastic reprocessing unit apparently is primitive, close proximity of individually managed units promotes a vibrant system of spread of technological innovation. There exist a collective system through which a new idea is easily picked up and further developed. For example, a local fabricator developed a method for production of *kodam* to avoid an entire round of extrusion, which is widely used by all other industries in Bangalore. The other case in reference is PVC coated light tension cable production in one of the slums in Delhi. Here 2000 such firms located in a neighbourhood control 30% of the country's market. Highly informal, home based existence of these industries produce 27 different varieties of cable which require fairly developed technical skills (Solomon, 1996).

6.1.3 ● Industrial Cluster

Other than playing an important role for technological innovations, clustering of individual units promotes competition in cooperation. It facilitates interaction among the industries to improve negotiation with market and authorities. They formulate self-regulatory mechanisms, e.g., the Karnataka Small Scale Plastic Manufacturers' Association in Bangalore or the Tamilnadu Plastic Manufacturers' Association in Madras. This also facilitates trade of machines, material and promote economy of scale.

All the above factors significantly contribute towards financial viability and profitability of these enterprises. It is suggested that a judgment about their efficiency and effectiveness based on inflow and outflow of the money might not prove appropriate.

Further Scope for Improvement

Given the not-so-simple nature of this industry, it may not be easy to suggest means for improvement. However, following points are made which may give clue for the same,

- Given their nature, these industries may have relatively higher cost of production compared to larger industries.
- To seek out ways to sustain their profit they may use cheaper inputs, pay low wages, and hire temporary or casual labor.
- Further technical improvements which may influence working environment or even quality of the product (unless it has market) may not be adopted.

This can have two fold impact on workers health and on quality of product. Simple process control measures and technological improvement can largely avoid pollution and health hazards. some example of which are suggested below,

- Washing of waste materials thoroughly before extrusion which substantially makes it less susceptible to degradation and reduces emission of hazardous gasses.
- Use of vented extruder which can remove moisture and gasses at the early stage of extrusion and further reduces chances of degradation.

However, it would be appropriate to mention that these measures may not be adopted by large section of plastic recyclers, not due to lack of knowledge or awareness but for the simple reason that they increase cost of production manyfold. Cost of production being function of various other factors it might not be easy task to influence plastic recyclers to change their practices.

Role of Government Agencies and NGOs

Plastic Recovery

Plastic is one of the most sought after waste items as it has huge business at waste trading and recycling level. It is high time that both waste recovery and trading activities are recognised and legitimized by the Municipal or Government authorities to at least minimise harassment of those dependent on it for livelihood. There are various ways by which municipal or government authorities can provide support to these activities, for example, provision of space for sorting and cleaning at subsidized or reduced rent. At more advanced level, it would be highly desirable if design of waste management technology and system take into consideration these informal activities and create more space for them.

NGOs can play crucial role by organizing those dependent on waste recovery and trading into cooperatives or any other organisational form which may be felt suitable. However, it would be important to note that such efforts should make the stakeholders more equipped instead of dependent on the organizing agency. For example, it is felt that provision of micro credit and

subsidized place for sorting, cleaning and storing waste materials can prove highly appropriate for a group of waste pickers or IWBs to improve their socio-economic and living standards. NGOs' support may be in terms of training in accounting and management and lobbying with the official agencies. At broader level, w NGOs can lobby for enactment of legislation in support of waste recovery and trading activities.

Plastic Recycling

- Development of safe and low cost technology for which it might not have capacity. At least it can provide institutional and scientific support for such innovations.
- Development and dissemination of safety, process and product standards in consultation with plastic associations and made mandatory.

The entire organisation of plastic recycling business may be much more complex than what it may be grasped through limited exposure for this research. Information generated for this research at least indicate that various forces such as national and international industrial policies, traditional community structure and its influence on financial viability of these industries are at work. Understanding of the interplay of these forces may take much more detailed study and wider sample, particularly before any suggestions are made for the improvement.

The real support may be provided to minimise occupational health hazards to which not only workers but the owners of the premises are also exposed, though in lesser degree. Here, probably NGOs can play a catalytic role in generating and disseminating information through its networking. They can also help by providing multidisciplinary consultation to the recyclers and their workers.

Basel Convention

The International Regulation of Transboundary Traffic in Hazardous Wastes, The 1989 Basel convention of which India is one of the signatories prohibits transboundary movement of

⇨Wastes from production, formation and use of resins, latex, plasticisers, glues and adhesives,
⇨Wastes collected from households (Kummer, 1992)

This is an important aspect as it influences issue of import of plastic waste and their environmental health impact and hence discussed here.

The “Basel Ban Proposal” sponsored by Nordic countries which prohibits transboundary trade of all waste including those meant for recycling, was unanimously adopted in March 1994. The amendment, although, did not include distinction between disposable and recyclable waste, it offers several loopholes which India could exploit in order to ensure continuous import of recyclable waste (EPW, 1995). The amendment also provides that the movement of the disposable waste be banned with immediate effect, while movement of recyclable waste be

prohibited from 1 January 1998. Hence India still continues to provide licenses for import of waste used as raw material. Although, recently a division bench of Supreme Court passed an interim order banning import of hazardous and toxic waste. The Court has directed the Center and the States not to issue any fresh import licenses for this purpose (Down to Earth, 1997). However it is important to note that definition of hazardous waste adopted by Basel convention differs from what is included in the Hazardous Waste (Management and Handling) Rules, 1989 of Environment (Protection) Act, 1986 of Government of India. In fact, India had earlier voted for the alternative draft of "Basel Ban Proposal" proposed by OECD countries, which made distinction between disposable and recyclable waste.

However within India, plastic processing and reprocessing industries are exempted from monitoring by Pollution Control Board. It is ironical enough that those requirements of International agreements which will affect the transnational movement would be better monitored, while those that have an impact at the local level - local consumers or workers or environment - would continue to be neglected.

Import of Plastic Waste

In reality import of plastic scrap for recycling may not be very attractive as it is projected. The entrepreneur who buys this plastic waste has to purchase it in large quantities viz. a container weighing 22 tons for which he /she requires enough storage space and capital to pay $260 per ton (1994 rates) (Saskia, 1994). However the case of PET bottles is different. Two plants in India has the technology to recycle PET bottle waste and they import waste for that purpose. Interestingly, PET waste from the municipal waste stream is not collected by the waste pickers as it has no market value due to limited capacity of both plants and cheap availability of clean waste from abroad. It is a point for discussion whether import of plastic waste would have any impact on domestic plastic recovery and recycling.

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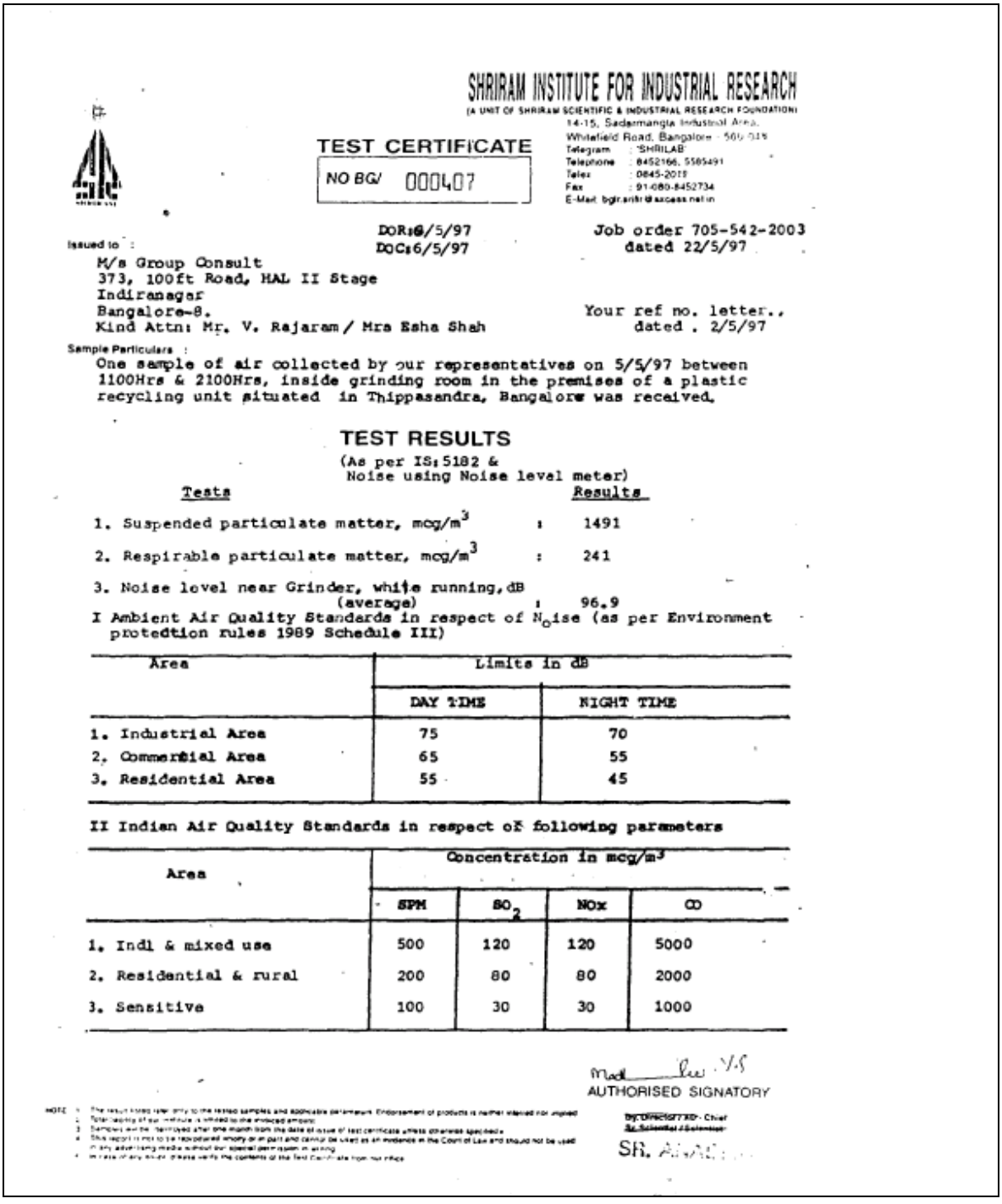
ANNEX 1 EXAMPLE OF CERTIFICATE



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TEST CERTIFICATE

NO BG/ 000407

DOR:6/5/97
DOC:6/5/97

Job order 705-542-2003
dated 22/5/97

Issued to :

M/s Group Consult
373, 100ft Road, HAL II Stage
Indiranagar
Bangalore-8.
Kind Attn: Mr. V. Rajaram / Mrs Esha Shah

Your ref no. letter.,
dated . 2/5/97

Sample Particulars :

One sample of air collected by our representatives on 5/5/97 between 1100Hrs & 2100Hrs, inside grinding room in the premises of a plastic recycling unit situated in Thippasandra, Bangalore was received.

TEST RESULTS

(As per IS:5182 &
Noise using Noise level meter)

Tests		Results
1. Suspended particulate matter, mcg/m^3	:	1491
2. Respirable particulate matter, mcg/m^3	:	241
3. Noise level near Grinder, while running, dB (average)	:	96.9

I Ambient Air Quality Standards in respect of Noise (as per Environment protedtion rules 1989 Schedule III)

Area	Limits in dB	
	DAY TIME	NIGHT TIME
1. Industrial Area	75	70
2. Commercial Area	65	55
3. Residential Area	55	45

II Indian Air Quality Standards in respect of following parameters

Area	Concentration in mcg/m^3			
	SPM	SO_2	NOx	CO
1. Indl & mixed use	500	120	120	5000
2. Residential & rural	200	80	80	2000
3. Sensitive	100	30	30	1000

AUTHORISED SIGNATORY

By Director/ XO- Chief
Sr. Scientist / Scientist

SR.

NOTE : 1. The results relate only to the tested samples and applicable parameters. Endorsement of products is neither stated nor implied.
2. Total liability of our institute is limited to the invoiced amount.
3. Samples are not destroyed after one month from the date of issue of test certificate unless otherwise specified.
4. This report is not to be reproduced wholly or in part and cannot be used as an evidence in the Court of Law and should not be used in any advertising media without our special permission in writing.
5. In case of any error please verify the contents of the Test Certificate from our office.

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NO BG/ 000425

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INDIRANAGAR,
BANGALORE - 560 008.
KIND ATTN.: Mr. V. RAJARAM.

705-542-2004 R
22/05/97

LETTER
02/05/97

Sample Particulars :

One sample of air collected by our representatives on 05/05/97 near Extruder (Plastic melting zone) inside the premises of a plastic recycling unit situated in Thippasandra, Bangalore between 11.00 Hrs. & 23.30 Hrs. was received.

TEST RESULTS

(As per IS: 5182)
(& Noise using Noise Level meter)

Sl.No.	TESTS	RESULTS DURING VIRGIN MATERIAL MELTING	DURING RECYCLED MATERIAL MELTING PROCESS
1.	Suspended particulate matter, mcg/m^3	: 409	---
2.	Respirable Particulate matter, mcg/m^3	: 202	---
3.	Sulphur dioxide (as SO_2), mcg/m^3	: 9	11
4.	Nitrous Oxides (as NO_x), mcg/m^3	: 16.3	21
5.	Carbon monoxide (as CO), mcg/m^3	: 2063	2916
6.	Hydrocarbons (as CH_4), mcg/m^3	: ---	16
7.	Noise level near Extruder when both grinder & extruder are running, dB (Average)	: 84.9	---

Med lcw. 7.5

AUTHORISED SIGNATORY

By Director / HOD / Chief
Dr. Rajendra Patwardhan

Sr. ANALYST

NOTE : 1. The result listed refer only to the tested samples and applicable parameters. Endorsement of products is neither intended nor implied.
2. Total liability of our institute is limited to the invoiced amount.
3. Samples will be destroyed after one month from the date of issue of test certificate unless otherwise specified.
4. This report is not to be reproduced wholly or in part and cannot be used as an evidence in the Court of Law and should not be used in any advertising media without our special permission in writing.
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