

Plastic waste management in Gedaref, Sudan : recycling options for plastic bags

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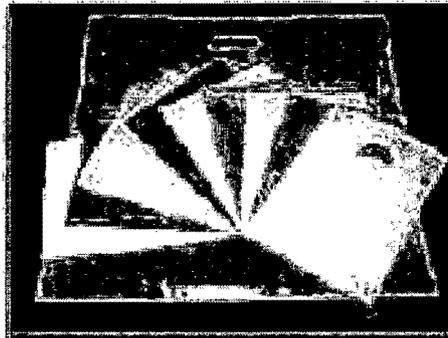
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Plastic Waste Management
In Gedaref, Sudan
Recycling options for plastic bags

Ellen Geurts
Eindhoven, December 2000

Plastics Waste Management In Gedaref SUDAN

Recycling options for plastic bags



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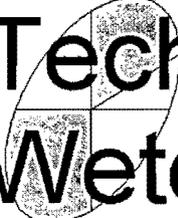
 **Techniek en Maatschappij
WetenschapsWinkel**

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Introduction

The municipality of Eindhoven is involved in a twinning project with the city of Gedaref, Sudan. In the past years co-operation has existed on different topics. The current topic is waste and water management. Waste management is the general outline for this particular research.

Waste management deals with three main issues:

- prevention of waste
- separation and collection of waste
- disposal or recycling of waste

For this particular research only one type of waste is studied, namely small plastic bags, used for packaging and transport of goods (mainly food) which is sold in shops and on markets. These bags are very light and since no system of collection exists they are scattered all over Gedaref by the wind. Especially in the rainy season this leads to a lot of obstructions and also a lot of animals are affected by the consumption of plastic bags. Moreover, water standing still in these bags is an excellent breeding place for mosquitoes.

For the troubles caused by the spread of these plastic bags a solution has to be found. Different angles can be chosen to formulate a solution. It is important to bear in mind that community participation is a very important prerequisite to make any solution work. If people are not willing to invest effort, time and money, and change their habits, nothing will succeed in the long run.¹

There is one very important limitation to this research. All information has been documented solely through a desk-study. The solutions are generated within that same framework. Since possibilities were generated through a desk-study only, all solutions have to be put into practice in Gedaref itself, to test the ultimate feasibility.

In Chapter 1 a brief background on plastics is given and an overview on the research set-up. Chapter 2 deals with the initial phases of solid waste management. In Chapter 3 the final waste management steps of disposal and incineration are discussed. Chapter 4 continues with the possibilities of recycling techniques. After that some general conclusions are given. The recommendations hope to give an outline to reach a decision in Gedaref itself.

¹ See Vogler

Chapter 1: Research proposal

1.1 Background of plastics

In recent years the economically less developed countries have increasingly adopted Western consumption habits, including the use of plastics. From a historical viewpoint, the development of plastics can be regarded as one of the most important technical achievements of the 20th century. Plastics are an excellent replacement for many different existing materials, which have more limited resources. Plastics are light, durable and versatile, to be used in countless applications. Plastic bags have been in use in Gedaref for the past 15 years.

However, the organisation of collection and disposal of plastic waste is not properly organised in many developing countries. Quite often this is the result from the absence of proper policy making. A process that has started in the industrialised world decades ago, controlled by strict environmental legislation. The process of policy making is slowly growing as well in developing countries. Due to a relatively low amount of plastic waste (1-5 % of municipal waste), plastic doesn't cause a huge impact yet. But with consuming patterns evermore changing towards Western consumption, it might be a big problem in the near future.

There is also the point of the economics of plastic recovery. Plastic is made from petroleum, an often scarce and expensive material in most developing countries. Virgin material for the production is therefore an expensive input material. For this reason recycled plastic can be an excellent substitute for the production of plastic products. It is important to emphasize at this point that recycled plastic is always an inferior product and also different from the original product.

1.2 Aim of research

To provide the city of Gedaref with a feasible option for disposal and/or re-use of plastic bags. Or alternatively with a suggestion for a different packaging material. The proposal is based only on existing methods.

1.3 Limitations of research

The research is performed as a desk-study and will be based on existing methods. The solution for the plastic bag problem in Gedaref will be based on applications in other, similar settings. No new systems will be designed for the purpose of this particular research.

1.4 Research problem

What is the most *feasible method* for waste management of plastic bags in the city of Gedaref, Sudan? More specific, which methods exist to recycle these plastics bags?

1.5 Approach

Method

An inventory is made on the existing methods for disposal and recycling methods of plastic bags.

Feasibility

Similar cases are studied. However, some of these cases might not have come with a solution either or found a solution by prohibiting the use of these plastic bags.

The real feasibility can only be established when the system is implemented in Gedaref.

1.6 Methods of data-collection

Search the internet and the library on existing information and study this information.

Write an e-mail to appropriate organisations (e.g. WASTE, SKAT, IHE) asking for advice and ideas.

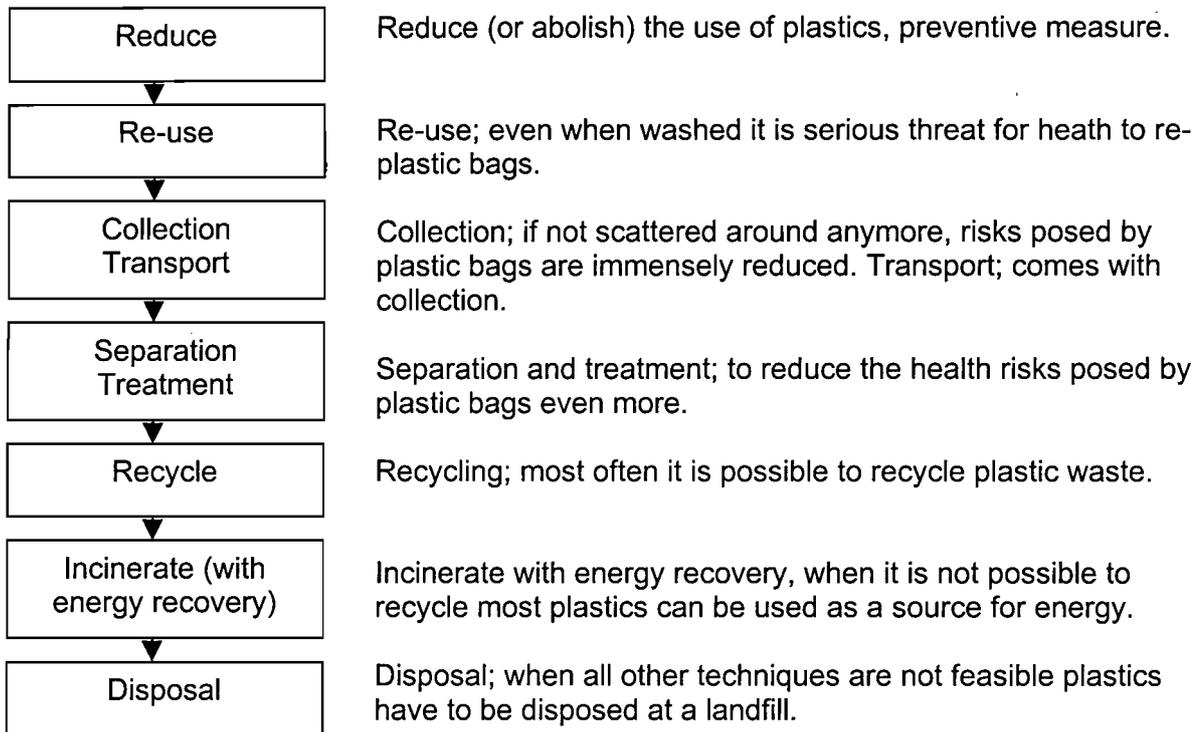
Write an e-mail to consultancy organisations concerned with developing countries and waste/recycling and ask for advice or ideas.

Interview professors concerned with polymer and plastic recycle techniques.

Chapter 2: Solid Waste Management

2.1 Phases of solid waste management

Solid waste management is generally divided in 7 different phases. This is also applicable for plastic bags. However, the main issue with waste management lies within the community itself. Participation is the key factor for success. The following phases can be distinguished, starting with the most preferable and ending with the least beneficial method.



The first three phases (reduce-transport) are dealt with in this chapter. In chapter 3 the last two are explained and chapter 4 deals with separation and recycling.

2.2. Identification of waste

Before a decision is reached on how to dispose or recycle the plastics it is imported to establish what kind of plastics are in use in Gedaref. This is an essential step since most plastics cannot be mixed in any recycling process.

First of all, the plastic bags in use are most probably thermoplastics (over time they can be changed and moulded, by using heat). Within thermoplastics there are three kind of Polymers: Polyethylene (PE), Polypropylene (PP) and Polyvinyl chloride (PVC).

To establish for certain which type of plastic is dealt with, some simple tests can help to establish this.

Test

1. Does the plastic float on water?
2. If the plastic is burned what colour does the flame have? Caution: when conducting this test be sure to hold the sample at a safe distance from the body and clothing. Do not breathe in the smoke.
3. What is the smell of the burning plastic? Bear in mind the distance!!!
4. Can you see scratches on the plastic (or does it stretch) when you use your fingernails?

Collect the answers to these 4 questions and try to establish with the use of table 2.2 which plastics you are dealing with.

Table 2.2

Test	Polyethylene	Polypropylene	PVC
Water	Floats	Floats	Sinks
Burning	Blue flame with yellow tip, melts and drips	Yellow flame with blue base.	Yellow, sooty smoke. Does not continue to burn if removed from flame.
Smell	Like candle wax	Like candle wax, less strong than PE	Hydrochloric acid
Scratches with finger nails	Yes	No	No

It is assumed that the plastic bags are made of Polyethylene, since most often plastic bags are made from PE. A second distinction has to be made when dealing with PE, whether it is high density or low density. High density PE (HDPE) is stronger, harder and crackles in the hand if crumpled. Low density PE (LDPE) is almost silent; it is soft and stretches more when torn. It is important to know this difference since the two cannot be mixed in production. It is expected that high density PE (HDPE) is in use in Gedaref, but this has to be confirmed in Gedaref.

2.3 Reduce

By reducing the use of a product, waste management will be solved in a great way. The most ultimate form of this would be the total abolishment of the use of plastic bags.

To see if this is an feasible option in the long run, it is important to look at the place of plastic bags in society and to see whether there is a technical alternative.

Plastic bags were introduced in Gedaref some 15 years ago. In this time span a rapid development of society has taken place. Less time is spent on shopping and shopping is less planned. People have got used to this rhythm of a more flexible life, just like in the West. An essential part of a more flexible life was supported by the introduction of plastic bags. Shopping did not have to be planned anymore. In the past, people had to bring baskets to the market to transport their purchases, nowadays the shopkeeper provides them with a plastic bag. These bags are especially handy for the transport of meat which is not ready-packed in Gedaref. 15 years is a considerable amount of time when it comes to developing behaviour. It is not likely that people will change this more flexible life-style, especially since society develops even more into a modern way of living.

So, even if there exists alternatives for the use of these plastic bags that are less damaging for the environment one has to bear in mind that they should guarantee the same kind of flexibility that plastic bags give.

The city council of Gedaref has recently introduced a new law, which makes it illegal to use plastic bags. Since goods still have to be transported an alternative has to be provided. The alternative is to return to using baskets and the use of paper bags. These paper bags are made from recycled cement bags. This solution is an example of the most preferable method: reduce. However, there are a number of reasons why the abolishment of plastic bags might not last.²

First of all, the city has implemented this law solely for Gedaref. It is quite difficult to maintain a law which is only applicable for such small area. For example, what to do if business men or seasonal workers bring bags with them from other areas? Whether it is possible to up keep this law will become clear in the near future.

However, if there are more cities who will implement this law, an other problem might occur. The abolishment of plastic bags needs an alternative in these other cities as well, quite possibly being the use of paper (cement) bags. In this case, demand for paper (cement) bags will rise and prices will go up. Cheap paper bags might than become a much more expensive substitute for plastic bags. People might not be willing to pay higher prices for a bag.

Especially since paper is inferior to plastic in this case. Think of the transport of meat and other "wet" goods, plastic is much better. It does not leak.

Another alternative is the use of baskets. This has some other drawbacks. Most people have got used to a more flexible life-style. Therefore they do not wish to plan their shopping anymore. Having to bring a basket does imply that shopping is planned again. It is highly unlikely that people will change this behaviour in the near future.

Whether the implementation of this law is successful will become clear in the near future. This report will provide some guidance in case plastic bags are going to be used again in Gedaref. Furthermore this report will help to establish whether plastic bags might have an economic value for Gedaref.

2.4 Re-use

Plastic bags should never be reused for their original purpose. There are some exceptions to this. If a person has carried only dry (non-food) products in a plastic bag, this same person can re-use this bag for a short while. But due to low quality this will be a rather short process. Large-scale re-use is impossible since it is a serious threat for health, even after washing.

Sometimes old plastics are bundled together to make ropes and things like that. It is quite unlikely that the plastic bags in use in Gedaref (PE) will have enough strength to be applied for this use.

A conclusion can be drawn that on an intermediate and long term, these plastic bags cannot be reused for any purpose, without jeopardising health.

2.5 Collection and transport

There are several methods for the collection of waste. Which method is best, depends on several related issues. Especially when plastics are collected for further recycling, some important issues have to be taken into consideration. Mixture, amount and cleanliness are important issues when plastics are going to be recycled. These issues can be influenced by the collection process.

² see www.angelfire.com/wi/PaperVsPlastic/

Since a household waste collection system is going to be set up in Gedaref it is most likely that plastics will be collected in the same way as the other household waste, being house-to-house collection. Generally speaking, the nearer collection takes place to the source, the less mixed and dirty the materials will be.

But whether it is possible to collect plastics on a house-to-house basis is not certain. For this reason, all possible methods of (separate) collection of recyclable material are given here.

These are:

- Drop-off centres: provision of collection containers
- Curb-side collection: source separation before collection or during collection (different bags or containers for different types of waste)
- Commingled recyclables: separation is done at central processing unit
- Co-collection system: plastics are separated in a different bag, but collected by the same vehicle
- Post-collection separation
- Buyback-centres; highly unlikely for plastic bags.

Whatever way of collection is chosen, transport is always needed. This goes for both household waste as well as recyclables waste. Since transport depends highly on the type of collection that is chosen, it is difficult to suggest modes of transport before hand.

In order to establish which waste (in- or excluding plastic bags) collection should be implemented, the following questions should be answered. These answers will help to establish the most feasible method.³

Questions

1. Which plastics are used by manufactures, both locally and elsewhere? If not, HDPE or LDPE, recycling opportunities are very small.
2. Do these manufacturers use reclaimed material and, if not, would they use it if good quality plastics were offered?
3. What price will they pay and for what degree of cleanliness?
4. What will the transport costs be if the user is far away?
5. Are there any types (colours, dirt), or quantities (too small or big) that they cannot take?

These questions lead us to the main question.

Is there a market for recycled plastic, i.e. plastic bags (LDPE or HDPE) in Gedaref or in a reasonable distance?

If not, study chapter 3 that deals with disposal and incineration.

If yes, study chapter 4 that deals with recycling techniques.

³ Vogler, 1983

Chapter 3: Incineration and Disposal

When there is no market for recycled plastic bags, recycling is not a good option. There are however two other options which will solve a lot of the current problems too. These are incineration and disposal and will be discussed in this chapter.

3.1 Incineration with energy recovery

Incineration is the controlled burning of wastes at high temperatures in a facility designed for efficient and complete combustion.⁴ The by-products of incineration are ash, gases and heat energy. In this case plastic waste could be burned for:

- Volume reduction
- Destruction of certain chemicals
- Energy recovery

This last reason is an interesting one for the case of Gedaref. If there are no possibilities for the recycling of plastics (either due to a lack of market or too low a quantity), the plastic could still be used as a fuel. This should only be done in industries where proper incineration is applied and is therefore not feasible on a small scale!

The burning of plastics will produce, on average, only 25% as much energy on a weight basis as that resulting from burning of fossils. Nevertheless, revenues from the sale of the energy recovery can significantly lower the cost of incineration. Industry known to use plastics as a source of energy is the cement industry in Tanzania.⁵

3.2 Disposal, landfill

If it is not possible to recycle or incinerate the plastic bags, the least to be done is disposal of the bags in a landfill. This is not an ideal solution at all. But it will solve a lot of the current problems.

- The plastics are not scattered all over Gedaref anymore.
- Goats or other animals won't be affected by eating the plastics any more. This involves that the landfill is a secured area, where no one can enter, without authorisation.
- When the bags are covered and mixed with soil, there won't be any water standing on them anymore. So if this is done properly, the risk of mosquito breeding is minimised.

So even a simple solution as a landfill solves most direct problems. On the long run, these landfills might damage both the environment and people's health. Therefore the location of a landfill and the maintenance is of great importance. This should be incorporated within the Waste Management Program currently on its way in Gedaref than.

⁴ see Katima and van Kasteren

⁵ see Katima and van Kasteren

Chapter 4: Separation, Treatment and Recycling techniques

Plastic recycling is most beneficial when the reprocessor can manufacture an end product. This is not always possible. And besides when there is no market for plastic products it is not beneficial either. In this chapter the different steps within the recycling process are explained. Each of these steps forms the plastic waste into an intermediate product that has most probably a market value. The more processes executed, the higher the market price, provided there is a market.

4.1 Initial upgrading techniques

Since the quality of the recycled product will be improved considerably if all contaminants are removed prior to reprocessing, it is important that plastics are separated as carefully as possible. Thus the waste plastics should be sorted, washed and dried. The order, in which this is done, is flexible. Especially the sorting is interrelated with the method of waste collection.

4.1.1 Sorting

It is very important that only the same type of plastics are put together. Any mixture of type of plastic will influence the recycling in a big way, quite often it is not possible at all, to recycle mixtures of plastics. It is also important to sort different colours of plastic. Since some colours of PE cannot be made into other colours (as a rule of thumb: dark colours cannot become more light). Dirt and dust should be shaken out. This process is mainly done by hand. If the plastic bags are relatively dirty it is better to do this step after the washing and drying.

4.1.2 Washing

It is important that waste plastics are being washed, because clean waste materials fetch better prices and improve the quality of the end product. Washing can be done, before, after or even during sorting. The plastics can be washed mechanically or manual. Manual washing can be done in oil drums (cut in half), baths tubs or specially built basins. The water is stirred with a paddle. Since some plastic bags are relatively dirty, hot water with soap or detergent should be used. Caustic soda can be used as well, provided that protective gloves will be used. Since bags are very light, it is probably not necessary to stir mechanically.

4.1.3 Drying

Drying can be done manually or mechanically too. Since there is plenty of sun in Gedaref, the manual method is probably most beneficial. After washing the plastic bags should be hanged outside in the sun. If they are put on a line they require only half the space than when they are laid out. It is important to secure them, so that the wind won't spread them all over Gedaref again.

4.1.4 Baling

If a potential market is over a fairly long distance, most often a better price is paid for baled plastic. This is easily done by squashing the plastics and tie them up. Usually the bale is a bundle, densely packed and tied in several directions with a string. At this point one should establish whether there is a possible market for this clean well-sorted plastic.

4.2 Size reduction techniques

Size reduction increases the density of the material. When materials are less dense, the transport costs are reduced. But also the smaller pieces are easier fed into further reprocessing machines. So, if this step can be established, a better price will be paid for the plastic waste.

4.2.1 Cutting

This step is not always necessary for plastic bags material. Some further processing machines however require smaller pieces. The easiest way of size reduction is simply by cutting the waste product. The plastic bags can very easily be cut up with the help of simple scissors.

4.2.2 Agglomeration (crumbing)

Since it is not advisable to feed soft plastics, such as plastic bags, directly into a shredder or extruder (used for further reprocessing) an agglomerator should be used in between. An agglomerator is used to cut, pre-heat and dry plastics. Agglomeration improves the quality of the end product and it will also increase the density of the material. It is important that material fed into the agglomerator is clean. In an agglomerator plastic is being cut so rapidly that the temperature rises. When it is just above melting point, water is poured to cool it rapidly. As a result the small pieces of granulated plastic become a coarse, uneven crumb. This crumbed material is easier to extrude and more dense.

4.2.3 Shredding (granulating)

The plastic is chopped into tiny pieces in a machine called a granulator. A drum with a knife at the bottom, passing close over two fixed blades. The bottom consists of strong mesh of the size of material required. Material that is too large to fall through the mesh remains above it until cut into small enough pieces. A small granulator of about 4 kilowatts can process 100 kg of material per hour. It is important that the material fed into a granulator is clean, selected to colour and polymer type (however LDPE and HDPE can be mixed). The end products are irregular pieces that can be sold to reprocessing industries and workshops.

Figure 5-5 Shredded PE.

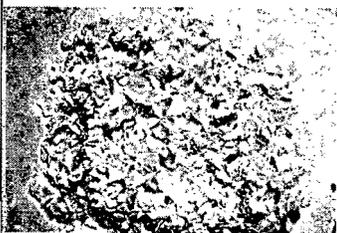


Photo: WASTE Consultants.

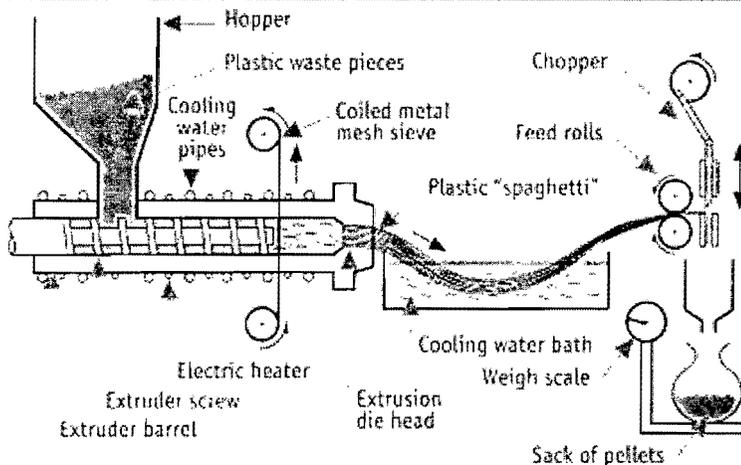
4.3 Further reprocessing techniques

The final steps of producing recycled materials are pelletizing and product manufacturing. These processes require small, uniformly chopped pieces, from the same polymer type. Most shredded and agglomerated waste plastics are pelletized before product manufacturing.

4.3.1 Pelletizing

Shredded rigid plastics and agglomerated film are subjected to the process of extrusion and pelletizing to produce plastic pellets.

Figure 6-2 Extruder with a pelletizer.



Source: Vogler,⁶⁵ 1984.

The materials are fed into a hopper. From the hopper they materials are picked up by a rotating screw, which forces them down a barrel. At the end of the barrel a slow moving screen or sieve removes grit from the plastic. Heat from friction and the heating elements fitted around the barrel cause plasticization and the material is also compressed by the heat. After the barrel the plastic is fed through the extrusion head. From this extrusion head the plastic comes out in a bunch of long strips. These pass through a water-bath, several feet long. The strings are cooled to become solid again. A pair of feed rollers keeps them moving. At the end of these rollers the strings are drawn into the pelletizer. Here a sharp edged, multi-bladed rotating knife chops the strings into small pellets. The pellets produced in this way are now suitable for feeding into an extruder, a moulder or a blown film line.

The production capacity depends on the size of the extruder. A small workshop needs at least three workers, where the person operating the extruder has to be a skilled person. Sheltered accommodation is required as well as water and electricity.

4.3.2 Product manufacturing

A number of mechanical manufacturing processes are used by small enterprises to produce final products, including:

- Extrusion
- Injection moulding
- Blow moulding
- Film blowing

The only suitable manufacturing process for PE is film blowing. For any of the other three processes PE (plastic bags) have to be mixed with granulates from other plastics.

Film blowing is however the most complicated process. And it is also important to bear in mind what the plastic film will be used for. It is highly likely that recycled film plastic has different UV-protection and therefore cannot be used as agriculture foils.

An example is given here of film blowing from plastic bags in Ghana⁶. Since the process requires quite a high level of skills, it is difficult to give a simple explanation here on this process. If this process is applied, the first step is to acquire trained personnel. They should be able to establish which machinery is needed and what plastics are fed into it.

Box 6.2 Plastics recovery with modern machinery in Accra, Ghana

Although there are various plastics manufacturing industries in Accra, Ghana, waste recovery is not common in this line of business. In fact, the only Ghanaian company engaged in reprocessing plastics is Polymers Ltd. The company's primary products are plastic films and flat sheets; plastics recovery only accounts for 10% of its business.

Besides the recovery of the company's own plastic waste materials, shopping bags (i.e. disposable packaging materials) are collected from special garbage bins. The collectors are trained to recognize the desired types of plastic waste. In the factory, women sort and wash the materials in metal drums to remove dust and other contaminants, such as oil or food. The washed plastics are dried on wooden platforms, and then fed into an extruder and pelletizer. The plastic pellets are dried and packed into bags, using the equipment shown in Figure 6-15. The processing equipment has been imported from Europe. The pellets are further reprocessed by remelting and blow moulding them. The pellets are sometimes coloured by adding pigment pellets into the hopper of the extruder.

The two kinds of end products are flat plastic sheets for table covers, rain and dust protection etc., and carrier bags for non-food container applications. The personnel and skills needed in the recycling process are shown in Table 6-2.

Table 6-2 Processes and personnel requirements.

<i>Process</i>	<i>Workers required</i>
Collection	3 unskilled contractors
Sorting	2 unskilled female workers
Washing/drying	2 unskilled female workers
Shredding	1 technician/operator
Extruding	2 operators
Pelletizing	1 operator

Other technical and administrative personnel include a sales and distribution manager, a technical manager, a general manager, an administrator and a secretary/bookkeeper. The total cost of the equipment for the factory was about \$3 million.

The reprocessed products can compete with other local and imported goods, used for the same applications. The bags, made from industrial plastic waste, are of good quality and therefore fetch good prices. In some locations, the bags are hardly distinguishable from imported ones, and are even sold for the same price.

Source: AB & P, 1992.

⁶ see Lardinois and van de KLundert

Conclusions

It is difficult to establish what the best waste collection method is and whether there is a feasible method for the recycling of plastics bags in Gedaref. To answer this question a field study is needed, or at least ample opportunity to consult people who are involved. Due to the limitations of this research, this was not possible.

The conclusions are listed on a basis of most preferable to least preferable method. The first three being general remarks.

1. Solutions for problems like these, depend very heavily on local situation, capacity and willingness. Policy-making could be an initial step for a solution. Sometimes solutions arise from the people themselves; this should most often be encouraged.
2. It is important to establish what the potential markets are, what they require and where they are?
3. Furthermore, it is important to establish what plastics are in use in Gedaref and what is the quality and quantity of these plastics.
4. From an economic point of view, recycling and manufacturing a new end-product is most beneficial. However, there are a lot of technical and societal drawbacks to this.
5. A less beneficial, but more likely option are the size-reduction and initial upgrading techniques. Both processes turn plastic bag waste into an intermediate product, which can be sold.
6. If quantity or quality are lacking it might be possible to incinerate, quite possibly with energy recovery. Establish which industries might use plastics as an energy source.
7. If it is not possible to even incinerate plastics with energy recovery than it is best to collect the plastic and cover them with soil at a landfill.
8. By using the recommendations, the city council of Gedaref should be able to establish which method for waste management of the plastic bags will be most optimal for Gedaref.

9. Recommendations

To establish the most feasible method for the recycling or disposal of plastics bags in Gedaref, the following questions have to be answered.

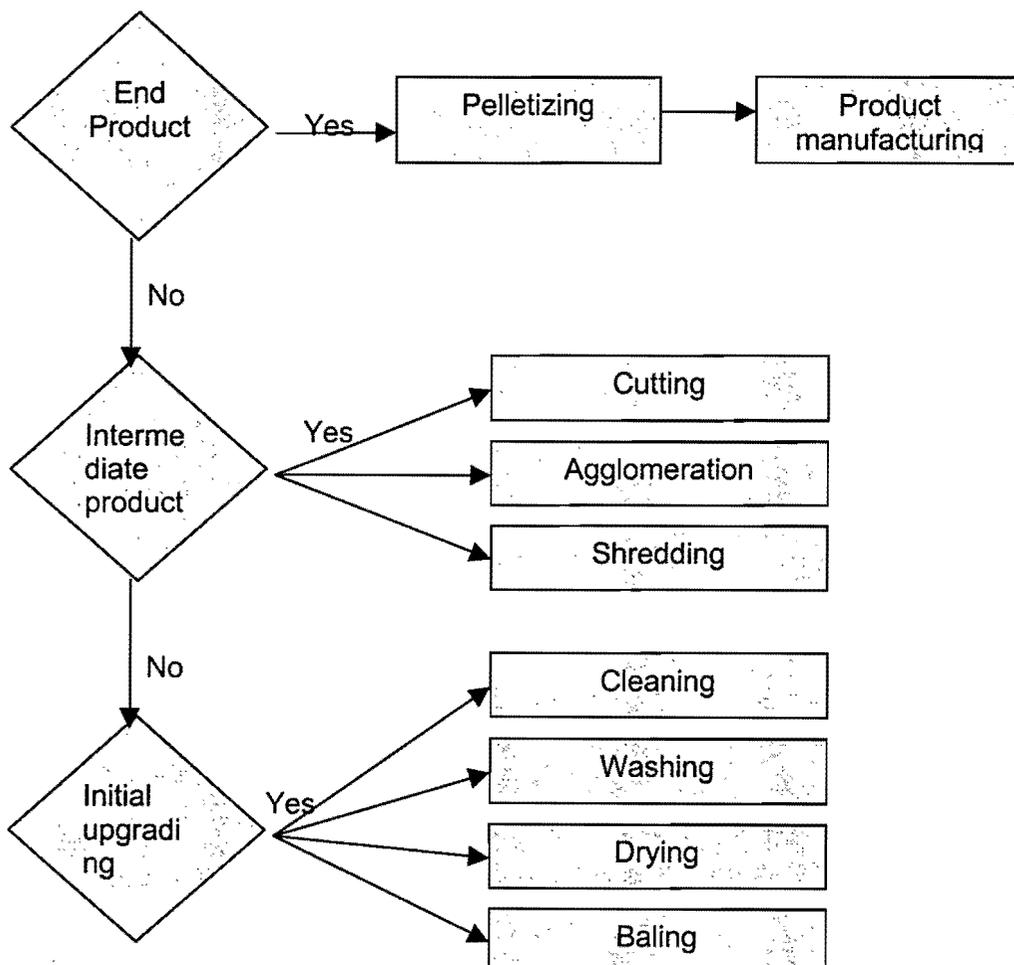
The first two questions are essential to answer (for explanations see the report).

Question 3 will establish whether it is beneficial to recycle and question 4 will list the recycling techniques.

1. What is the type of plastic? See box page 7.
2. What is the quality and quantity of plastic bags in Gedaref? (consider the level of dirt and the amount when all plastic is collected)
3. Is there a potential market for intermediate or end-products of plastic? What are the market requirements? See box page 9.

If there is no market, study chapter 3. Consider disposal or incineration.

4. Establish which product the market for recycled products wants (end, intermediate or upgraded)? See figure below



Study chapter 4: recycling techniques.

Consulted literature and other sources

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