

# A Study of Recycling in the Recovery Hierarchy of Reverse Logistics

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**Abstract:** All businesses have forward as well as reverse flows of goods. The forward flow moves from the supply of raw material to the end user. The reverse flow moves counter to this forward flow. There are multiple reasons and outcomes of the reverse flow of goods. One such outcome is recovery of material or energy. There are several recovery options in the recovery hierarchy which need sound evaluation. Organizations have started focussing on various recovery options in reverse logistics for economic, customer and environmental reasons. One such strategic option is recycling which is the recovery of materials from rejected/ used/ end of life/ obsolete products or waste. The paper presents the recycling process and its place in the Recovery Hierarchy. It covers the definition, reasons, advantages and concerns about recycling. It gives an insight into the importance of recycling in the area of material recovery management in reverse logistics.

**Keywords:** Reverse Logistics (RL), Recovery Hierarchy, Recovery Options, Recycling

## Introduction

Rogers D.S. (1998)<sup>1</sup> has explained reverse logistics (RL) in their unique book *Going Backwards: Reverse Logistics Trends & Practices*. RL is the process of planning, implementation, and controlling the efficient and cost-effective flow of various materials such as raw materials, in-process inventory, finished goods and associated information from the point of end-user to the point of origin. The end purpose is to recapture value or correct disposal. More specifically, RL is the reverse flow of goods from their last destinations for re capturing value or correct disposal. The definition may also include remanufacturing and refurbishing activities. Growing concern for green supply chains makes it more relevant to focus on reverse logistics.

The returns can be broadly classified into three types:

1. *Manufacturing Returns:* raw materials, excess materials, rejections, leftovers, byproducts.
2. *Distribution Returns:* product recalls, stock returns, and commercial returns.
3. *Customer Returns:* Guarantee/ warranty returns, service returns, end of use/ end of life returns.

The RL process moves from product collection to inspection, separation, sorting till final disposition. The various options in RL could be return to seller, reuse, resell, redistribute, salvage, repair, recondition, refurbish, remanufacture, 'recycle', donate, disposal through incineration or to landfill.

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There are a number of disposition options available in RL to fulfill the economical, legislative and social obligations. The process of 'Recycling' is one of them. 'Recycling' is the recovery of parent materials from rejected/ used /end of life/ obsolete or waste materials. 'Recycling' involves collection, sorting, processing of the materials to its original form so that it can be reused as inputs for manufacturing products of similar or other designs. One prime reason is saving of scarce materials which we extract from mother earth. The result is cost effectiveness and reduced environmental damage. In this research paper the study of 'Recycling' as a material recovery option in the recovery hierarchy is presented.

## **Objectives**

The paper intends to fulfill the following objectives:

- To understand the meaning of reverse logistics and its drivers.
- To study recycling as a material recovery option.
- To understand the reasons, advantages and concerns about recycling.

## **Research Methodology**

The findings presented in this paper are the outcome of the survey of literature conducted by the researcher. A review of the secondary data in the area of materials recovery management under reverse logistics was done. A number of articles and research papers on reverse logistics and materials recovery options were referred. Websites of various organizations were studied for getting information about the drivers of reverse logistics. The reasons for recycling were explored from different sources. The outcome of the review of the recycling practices and their pros and cons are given in the conclusion section of this paper.

## **Reverse Logistics**

### **Definitions**

The definitions and meaning of reverse logistics by some of the authors/ organizations are given in this section.

Business dictionary<sup>2</sup> gives the definition of Reverse Logistics as the movement of the unwanted or excess materials, in process products or finished equipment back to the manufacturing firm. The reasons for this reverse movement through their logistics chain could be for 'Recycling', reuse or final disposition.

James R. Stock (1998)<sup>3</sup> has given his definition at the Council of Logistics Management in 1998. He says that the term 'Reverse Logistics' is in reference to the logistics role in returns of goods, reduction of sources, substitution of materials, 'product recycling' and disposal of waste. It also covers repairs, refurbishing and remanufacturing.

According to Bearing Point (2008)<sup>4</sup>, RL denotes a set of planning, implementation and control measures of the flow of raw materials and final products so as to recover and 'recycle' those materials or products. It involves a wide range of actions, including collection, sorting for further processing and reconditioning.

According to Guide, *et al.* (2000)<sup>5</sup>, RL is the task of recovering the discarded products; including shipping and packaging materials and backhauling them to a central collection area for either remanufacturing or 'recycling process'.

Karen Hawks (2006)<sup>6</sup> includes a wide range of actions. It covers the returns goods processing resulting from goods damage, seasonal inventory, salvaging operations, recalled inventory, end of use returns, end of life returns. Its scope also includes various 'recycling programmes', hazardous materials processes, obsolete components and equipment disposition and different asset recovery options.

According to Vogt *et al.* (2002)<sup>7</sup>, RL is the management of all activities involved in flow of goods, demand information and money in the direction opposite of the primary forward logistics flow. It involves reduction in the waste generated, as well as the management of collection, transportation, disposition and 'Recycling' of both types of hazardous and non-hazardous waste in a way that increases the long-term profitability of the organization.

Carter and Ellram (1998)<sup>8</sup> explain Reverse Logistics as a process whereby organizations can be more environmentally efficient by 'Recycling', Reusing and Reducing the amount of materials used. It is the reverse distribution of materials amongst channel members. It facilitates the 'Recycling' and reuse of material thereby reducing the total material inputs.

A review of above definitions points out that these authors have included 'Recycling' under the scope of Reverse Logistics. The collection, sorting and processing of returned products to extract materials suitable for reuse is known as 'Recycling'. It is an important part of the RL cycle. Some products which cannot be reused for technical, obsolescence or cost reasons can be recycled to recover the parent material. Organizations are adopting the recycling process for economic, legislative, environmental and social responsibility reasons. Under this, the returned products are processed by using appropriate technologies. These result in new materials which are available for use in same or different supply chains.

### **Reverse Logistics Drivers**

There are several reasons for Reverse Logistics. Products are returned as they are not functioning properly or stopped to perform. They could move in reverse direction from any of their channel positions in supply chain.

Carter and Ellram (1998)<sup>8</sup> put forth a model of forces which stimulate and restrain RL. They have identified four environmental forces:

1. Government (in terms of regulations).
2. Suppliers.

3. Buyers.
4. Competitors.

The RL activities are either forced or done proactively for economic reasons. Generally organizations get involved in RL because they can profit from it or/ and they have to do it or/ and they feel socially motivated to do it.

Brito and Dekker (2003)<sup>9</sup> have mentioned three drivers of RL. These are:

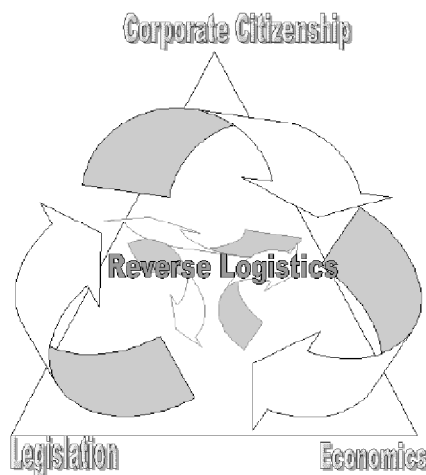
1. Economic (Both Direct and Indirect).
2. Legislation.
3. Corporate Citizenship.

**Economic:** These are the benefits as a result of direct reduction of material consumed, addition of value on account of recovery of materials or energy and the reduction in disposal costs.

**Legislation:** It refers to the various laws of the land pertaining to product manufacturing, consumption, recovery and disposal. It also includes laws on packaging and its disposal. Different countries have enacted various legislations to protect the rights of consumers and the environment. It includes Producers Extended Responsibility.

**Corporate Citizenship:** It talks about environmental accountability. It includes the values and principles adopted by the RL company for being a responsible corporate entity. It shows their responsibility towards the society and environment and is their feeling of doing good for society and environment without any compulsion.

These three drivers are given in the Figure No. 1 below:



**Fig. 1: Reverse Logistics Drivers Triangle**

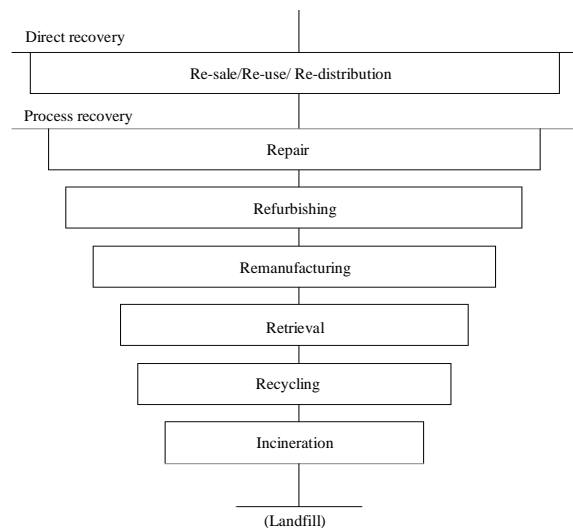
Source: Adapted from Brito and Dekker (2003:8)<sup>9</sup>

The arrows in the figure depict that the three drivers are not mutually exclusive. All are overlapping and are playing their roles of RL drivers. Different situations and products would have varying pulls from these drivers. Also these are country dependent as different countries are having their own set of customer and environmental legislations.

### Reverse Logistics Recovery Options

According to Brito and Dekker (2003)<sup>9</sup> the recovery options are the various methods of recovery and recapturing of value in the RL process. Actually, the process of recovery is an intermediate phase of the total RL chain. The four phases are explained below:

1. **Collection:** The first phase is of collection which involves bringing the material from the customer.
2. **Inspection, Selection and Sorting:** Assessing the quality and deciding to send it through appropriate channels depending on the inspection results. If quality is appropriate, it can be reused, resold or redistributed. Otherwise, the suitable recovery option is adopted.
3. **Recovery Process:** Involving some minor or major work as required for capturing the maximum value, or adopting any of the recovery alternatives as per the different levels as given in the Figure No. 2. It can be Repaired (Product level), Refurbished (Module level), Remanufactured (Component level), Retrieval (Selective part level), 'Recycling (Material level)' and Incineration (Energy level).
4. **Redistribution:** The final phase is of redistribution to the channel partners as per requirements. If none of the recovery options are possible for technical or economic reasons, then the material is sent to landfill.



**Fig. 2: Inverted Pyramid of Recovery Options**

Source: Adapted from Brito and Dekker (2003)<sup>9</sup>

The recovery options at different levels as explained above are shown in Fig. 2: Inverted Pyramid of Recovery Options. It is also called as the Hierarchy of Recovery.

It is not necessary that the recovery options at the top of the pyramid are of high value, or are more environmental friendly as compared to the lower end options. It depends on the economic value of the selected recovery option which varies from product-to-product. The existence for corresponding market also decides the value in RL chain.

## Recycling

According to Brito and Dekker (2003)<sup>9</sup>, there is a dilemma for what to do with returns. As discussed in previous section the Recovery Process can involve some minor or major work as required to capture maximum value. Organization can adopt any of the recovery alternatives as per different levels.

- Product level
- Module level
- Component level
- Selective part level
- Material level
- Energy level

Refer to the Inverted Pyramid of Recovery given in Fig. 2. In some situations the materials can go through the phase of Recycling (Material level) rather than moving to Incineration (Energy level) or going to the landfill. The reasons for choosing this recycling could be economic, legislative or social.

Above levels are known as 'Recovery Hierarchy'. Recovery at the Recycling level is generating new materials by using the material which could not be recovered in the upper phases of this hierarchy from Product level to Selective part level. Here the form of the product changes. This recovery process is called as Recycling in which the returned material is processed using suitable technologies and converted to new usable material. This reuse could be in the same supply chain, manufacturing similar products or other supply chains producing other products.

It is just unsustainable in the short and long run to send the returns for Incineration i.e. burning or to landfills for final disposition. Both, incineration and landfill options lead to pollution of land, water and air. Hence, the best option in the recovery hierarchy before Incineration and landfill is recycling.

Conserve Energy Future<sup>10</sup> gives the 3 Rs for a sustainable future. The 'Reduce, Reuse, Recycle' Waste Hierarchy is the order of priority of the actions to be taken to reduce the quantity of waste generated and to develop overall waste management processes and programmes. The waste hierarchy consists of 3 Rs as follows: Reduce, Reuse and Recycle. Called the "three Rs" of waste management, this waste hierarchy is the guidance suggested for creating a sustainable life.

**The First ‘R’–Reduce**

It is the concept of reducing what is produced and what is consumed and the first R in the waste hierarchy. The logic is simple to understand. If there is less waste, then there is less to recycle or reuse. The process of first R reducing begins with a scrutiny of what you are using, and what it is used for.

**The Second ‘R’–Reuse**

Learning to reuse items, or re-purpose them for a different use than what they were intended for is the second essential in waste hierarchy.

**The Third ‘R’–Recycling**

The final stage of this waste hierarchy is to recycle. To recycle a product means that it will be converted again into a raw material that can be formed into a different item. There are very few materials on the earth which cannot be recycled. Much development is being made towards integrating recycling plants with industries that can process the waste material. One needs to recognize as to which products can be recycled and which cannot. Carefully choosing the products that can be recycled will be the first step towards effective recycling.

Recycling Revolution<sup>11</sup> gives an easy-to-use list of the materials which can be recycled. Aluminum cans, steel cans, copper, other metals, newspaper, magazines, paper packaging, plastics. The list of industrial components which can be recycled can include automobile parts, tyres, batteries, consumer durables, electronics equipment, construction waste, medical waste etc.

***Company List–recycling Companies in India<sup>12</sup>***

There are over hundred companies in India doing recycling of agricultural produce, automobiles, chemicals, construction materials, electrical equipment, industrial equipment, medical waste, metals, paper, plastics, rubber and textiles. These are mostly concentrated in the industrial belts. They cost effectively cater to the material requirements of the industry and reduce the adverse impact on environment.

Stakeholders<sup>13</sup> in recycling business, include investors, owners, government agencies, environmental groups, customers, citizens, employees and suppliers. All play a role in the recycling business which is an important component of the reverse logistics.

***Environmental Laws of India<sup>14</sup>***

Central Government of India has notified rules under Environment (Protection) Act, 1986 for dealing with non-biodegradable solid waste materials causing environmental hazards when released into land, water and atmosphere. The dangers are so vast that India alone generates about 800 to 3,200 tons of plastic waste per day. These rules pertain to the manufacture, use, collection, segregation, transportation and disposal of recycled plastics carry bags and containers. These rules are enforced by the State Pollution Control Boards. These are applicable to vendors selling

foodstuffs. They cover prohibition of usage of carry bags or containers made of recycled plastics for storing, carrying, dispensing, or packaging of foodstuffs. Manufacturers of recycled plastic carry bags shall code/ mark carry bags and containers. Manufacturers shall print on each packet of carry bags as to whether these are made of 'recycled material' or of 'virgin plastic'. The minimum thickness of the carry bags produced from virgin plastics/ recycled plastics shall not be lesser than 20 microns.

### **Definition of Recycling**

Dictionary<sup>15</sup> meaning of Recycling is to treat or process used or waste materials so as to make suitable for reuse. It means, to make something new from what has been used before, to process in order to regain the material for use.

As per Calrecycle<sup>16</sup>, recycling is using waste as material to manufacture a new product. Recycling involves altering the physical form of an object or material and making a new object from the altered material. Recycling is not total waste prevention because only waste generated can be recycled. One must generate waste in order to recycle the waste. Therefore, if you are recycling, you have already created waste. Although recycling is a desired thing, ideally it would be better to not generate any waste. Of course, recycling consumes less energy and resources than making new replacement items with virgin material. With recycling, you normally need to collect a material, transport it, clean and sort it, transform it, market that transformed material, make the converted material into a new product, package and market the product. Manufacturing a product out of recycled materials is environmentally better than using virgin materials.

### **Reasons for Recycling**

Socra<sup>17</sup> gives 10 Reasons to Recycle:

1. **Good for the Economy:** Businesses get the required raw materials to produce new products.
2. **Creates Jobs:** Millions of workers are employed for recycling operations which are mostly labour intensive.
3. **Reduces Waste:** Effective recycling reduces overall wastage and flows towards landfill are reduced.
4. **Good for the Environment:** Recycling consumes far less energy, uses lesser natural resources, and reduces waste from heaping up in landfills.
5. **Saves Energy:** Recycling offers noteworthy energy savings over production with virgin materials. (Manufacturing with recycled aluminum cans uses 95% less energy).
6. **Preserves Landfill Space:** No one wants to reside near a landfill. Recycling preserves existing landfill space. Land is very costly and the saved land could be used for more developmental projects.



7. ***Prevents Global Warming:*** Recycling of solid waste checks the discharge of tons of greenhouse gases into the atmosphere.
8. ***Reduces Water Pollution:*** Producing goods from recycled materials creates far less water pollution than from virgin materials.
9. ***Protects Wildlife:*** Using recycled materials lessens the damage to forests, rivers, wetlands, and other habitat essential to wildlife.
10. ***Creates New Demand:*** Recycling and purchasing recycled goods generates additional demand for recycled products, thereby reducing waste and aiding our economy.

### **Advantages of Recycling**

Conserve Energy Future<sup>18</sup> mentions some Advantages of Recycling:

1. ***Protects Environment:*** The notable benefit of recycling is that it supports in protecting the environment in the most stable manner. While countless trees are chopped down continually, recycled paper produced from certain trees is reused repeatedly to curtail deforestation. With recycled paper as an exceptional example, many other natural resources can be recycled and used this way.
2. ***Reduces Energy Consumption:*** A huge amount of energy is consumed during processing raw materials. Recycling helps to reduce energy consumption, which is critical for massive production such as refining or mining. This makes the manufacturing process very beneficial and cost-effective for the manufacturers.
3. ***Reduces Pollution:*** Today, Industrial waste is the highest source of all types of pollution. Recycling of industrial products such as chemical, plastics, and cans assists to reduce pollution levels significantly, as these materials are reused rather than throwing them away irresponsibly.
4. ***Reduces Global Warming:*** Recycling aids in reducing global warming and its adverse effects. Huge amount of waste is burned in piles which emits large amount of greenhouse gases such as CO<sub>2</sub> and CFCs. Recycling ensures that this burning process is decreased and any waste is regenerated as a valuable product with no or minimal detrimental impact on the environment. Recycling produces fewer greenhouse gases as industries burn lesser fossil fuels for producing eco-friendly products.
5. ***Judicious and Sustainable Use of Resources:*** Recycling encourages sustainable and judicious use of resources. It ensures that there is much lesser discriminate use of material when presently available in plenty. Recycling is encouraged at all levels from school to corporate offices at international levels. The result is preservation of all precious resources for the future generations, without any compromise for the present.

6. **Conserves Natural Resources:** If used and old materials are not recycled, then the new products are manufactured from extracting fresh raw materials from under the earth through extraction and mining. Recycling helps in saving important raw materials and safeguards natural surroundings for the future. Conserving the natural resources such as minerals, wood and water ensures its optimal use.
7. **Reduces Volume of Waste to Landfills:** Recycling of old and waste products into new products decreases the amount of waste going to landfills. This benefits in reducing pollution of land and water as landfills are the main sources in contributing to the damage of natural environment. Recycling programmes prevent tons of waste from being dumped into landfills every year.
8. **Create Green Jobs:** Recycling is helpful for the environment and also generates green jobs. Recycling requires a lot of labour for the various activities of collection, sorting and processing.

### Concerns of Recycling

Andrew Handley (2013)<sup>19</sup> has cautioned about the adverse impacts of recycling, on the environment:

1. **Recycling Gives False Promises:** It's the mindset it gives to the people. The idea is that by putting materials in the recycle bin, by buying products made from recycled material, we're saving the environment but it is not really contributing to reduce and reuse.
2. **All-In-One Recycling is Inefficient:** There's the problem of quantity versus quality. All-in-one recycling centres emphasis on speed which introduces extra contamination issues.
3. **Some Products are Better Left Unrecycled:** Products like glass which requires sand, the most abundant resource on the planet. Recycling of glass is more detrimental than the processing of virgin glass.
4. **Recycling Barely Dents Demand:** The demand for many recyclable products is growing too fast to keep up with anything that recycling can provide.
5. **Oil Refining Creates Toxic Chemicals:** Some recycling processes having oil emit toxic gases during reprocessing.
6. **Current Methods Aren't Effective:** The present available technology is not that effective to control the adverse effects of recycling on environment.
7. **Most Plastics Can't be Recycled:** Not all plastics can be recycled and if done leads to contamination problems and is harmful to health.
8. **Paper Sludge is Just Disgusting:** Some byproducts of recycling are too harmful to environment.

9. ***Air Pollution is Still a Problem:*** Recycling has its own set of air pollution issues.
10. ***Contamination Gets Around:*** The issue of contamination of packaging materials for food products due to recycling is a great risk to human health and environment.

### ***Conserve Energy Future<sup>18</sup> Point Out Certain Disadvantages of Recycling***

1. ***Not Always Cost Effective:*** Recycling is not always cost-effective. Sometimes, there may be a need to establish dedicated factories to process reusable products. This may generate more pollution as they would undergo the process of storage, cleaning and transportation.
2. ***Recycled Products May not Last for Long:*** Products from recycled materials are not always durable. Such items are generally made of trashed waste, handpicked from heaps and other waste products which are of fragile or used overly. For this reason, recycled products are cheaper and generally last for a shorter period.
3. ***Unsafe and Unhygienic Recycling Sites:*** Recycling sites are generally not safe and also unhygienic. Places where all types of waste are dumped are favourable for debris formation and spread of disease and related dangers caused by harmful waste and chemicals. This causes widespread pollution and is harmful for people who recycle such products. Such waste mixed with water leads to leachate formation and contamination of water bodies including drinking water.
4. ***Not Widespread on Large Scale:*** Although recycling is an important step to curtail pollution, unfortunately this process is just a minor part of long-term success. Recycling regularly occurs on a smaller scale at homes, societies or schools and has failed to be useful at a larger level such as at industries or at a global level. Saving paper at schools level cannot be compared to the large oil spills or massive tree felling at industrial level.
5. ***High Initial Cost:*** Setting up a new recycling unit involves very high cost. This huge cost can come up as a part of acquiring different facilities, upgrading the processing units, educating residents through seminars and other programmes, disposing of existing chemicals and waste etc.

According to Mary Bauer (2015)<sup>20</sup>, “The Negative Effects of Recycling Paper” gives some adverse effects about recycling of paper:

- Energy consumption is not effective in many situations and leading to higher energy costs in recycling of paper.
- Harmful chemicals are produced as byproducts of recycling requiring further treatments to safeguard the environment.
- Water pollution is the result of many recycling programs due to the removal of inks and other toxic materials.

- Solid waste generated during recycling is also having chemicals which are harmful to human beings and environment.
- Encouraging Consumption: Recycling programs advertise about their care about planet and society encouraging people to purchase and consume more recycled products.

## Conclusion

Reverse logistics covers many activities including recycling. The drivers of reverse logistics are economic, environmental and legislative. Recycling is an important step of the Recovery Hierarchy and a crucial recovery option. It is an inseparable part of the 3R philosophy. Whether it's profitable or not, recycling must go on because of the imbalance between limited natural resources and human material demand. It comes into picture after the previous options of Reduce/ Reuse/ Repairs/ Refurbish/ Remanufacture/ Retrieval are not possible for economical, obsolescence, environmental or legislative reasons. Many sectors have scope of recycling of a number of materials.

The recycling is having advantages as reduced waste generation, lesser dependence on virgin materials leading to lesser mining activities and its related problems, reduced energy consumption, lesser land/ water/ air pollution, reduced adverse environmental impacts, more employment generation, reduced landfills, reduced global warming, and protection of wildlife. Overall it is good for sustainable economy and environment.

Not all is positive about recycling. The initial costs of recycling plants are high. Recycling generates air/ water/ land pollution, some of the residual waste and byproducts are harmful. There are issues of safety and contamination of a few recycled products. Recycling is not sufficient to meet demand of materials. Also, all materials are not recyclable and some are not cost effective.

According to Eco Cycle<sup>21</sup>, "Recycling isn't the only answer. Recycling alone will not stop resource destruction but it's a significant step along the way to a world of Zero Emissions and Zero Waste. Zero Emissions refers to reducing emissions from transportation, energy and production by choosing alternate means of travel, substitute fuels, preservation, efficiencies, and renewable rich and non-polluting sources of energy like wind and solar. Zero waste refers to redesigning our manufacturing and consumption systems to utilize resources more efficiently, to avoid waste before it happens and to integrate all leftover materials back into the manufacturing cycle rather than dumping them as waste. If we combine Zero Emissions and Zero Waste together, we would get our solution.

Government should encourage recycling over other disposition options of incineration and landfill by giving incentives so as to protect the resulting environmental damage, businesses to design products in which the recovery can happen at the product/ module/ component/ part level. Also, they should target using some portion of recycled materials; purchasers to buy only those

products which are made from recycled materials. They should adopt the philosophy of Reduce, Reuse and Recycle. Consumers to stop wasting and avoiding excessive consumerism and support Industries using recycled materials. All stakeholders should understand the recovery hierarchy and support the 3R philosophy.

After weighing, the pros and cons of recycling, one can wisely take the right decisions related to this process. Understanding the impact of recycling is needed on a large-scale which if effectively done can bring in substantial positive results, beneficial to survival of human beings and environment.

A famous proverb says that, “we do not inherit the earth from our ancestors, we borrow it from our children”. This holds true for all the resources we get from mother earth. The scarcity of these resources needs to be understood and steps taken to use the reducing resources conservatively. Recycling aims at reduction and savings of the scare materials and thereby having a positive impact on the environment.

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